12

INDUSTRIAL AND TECHNOLOGICAL MUSEUM,

MELBOURNE.

LECTURES

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INTRODUCTORY NOTE.

THE Third Series of Lectures delivered in the Lecture-room of the Industrial and Technological Museum, Melbourne, is now offered to the public.

The Committee desire to express their thanks to the gentlemen who, by their lectures, have assisted the Committee in their efforts to promote knowledge in Science and Art.

INDUSTRIAL AND TECHNOLOGICAL MUSEUM,
17th May, 1872.

THE GEOLOGICAL ACTION OF FIRE.

A LECTURE,

DELIVERED BY FREDERICK M'COY

(Professor of Natural Science in the University of Melbourne, Director of the National Museum, and one of the Technological Commissioners),

On 21st SEPTEMBER, 1871.

THE subject selected for this evening is the geological action of fire. It is particularly desirable to have a clear knowledge of this powerful geological agent as preliminary to almost all geological study. You will find that the most simple and elementary parts of geological research require some knowledge, and tolerably exact knowledge too, of the way in which fire acts in its geological relations both to the structures of the great rock-masses, and the general conformation of all the older rocks—from which those less old have been subsequently formed, by various mechanical and chemical changes.

I have placed a number of rock specimens on the table, which furnish good examples of all the more ordinary "Igneous Rocks," as they are termed, and they show the comparatively few mineral ingredients of which all the rocks manifestly formed by the agency of fire are composed. If you examine these carefully when you have more leisure and better light, in the day-time, you will find such study by the eye greatly to facilitate your advance in geological knowledge, particularly of that portion of it called "Lithology," which may be taken in any point of view as a necessarily preliminary portion of all systematic practical geological investigation.

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* This lecture is printed from the reporter's notes, as revised by Professor M'Coy.

The most important study as to the direct action of fire, in a geological point of view, may be made in the various localities of the earth affording examples of what are commonly called "active" volcanoes, such as Vesuvius or Etna.

In all eruptions of active volcanoes, you have in distinct action this great geological agent, actually forming before your eyes a number of rock-masses of almost all the varieties of the newer kinds of igneous rocks, under circumstances and peculiar local conditions which are seen to be capable of producing great differences in the general appearance of the different recognised kinds from a nearly uniform material; a fact readily to be understood when you see these causes producing the effects during an ordinary volcanic eruption.

In existing volcanoes you find the most universal characteristic is the outpouring of great rock-masses in a melting condition, or of pulverulent, dry, dusty, or cindery masses mineralogically identical with them, from the volcanic craters. It is a matter of great delight to the geologist to find that the melted rocks which he sees thus flowing out from the interior of the earth, and cooling and solidifying almost under his foot—that these rock-masses forming under his eyes are identical with those he finds in the earlier periods of the world's history, forming great thicknesses of the earth's crust; so alike, in fact, that it is in many cases almost impossible to tell one from the other.

On looking at any ordinary volcano, as, for instance, Vesuvius, which we have sketched here on the black-board, you commonly see the appearance here represented and described by old Italian geologists as resembling a pine-tree, that sort of pine-tree you see in Turner's Italian Landscapes, being apparently a narrow cylindrical column of smoke rising from the aperture at the top of the mountain to a great height, and then spreading out like an Italian pine, or an umbrella, or mushroom. This is not really smoke, but a mass of pulverulent fine dusty particles of the very common minerals which compose the great flows of melted "lava," as the boiling rock which pours down from the craters is called.

These dust-like particles, composed chiefly of minute crystals of igneous minerals, get into the higher regions of the atmosphere, and are carried by currents of air sometimes hundreds of miles over the land or out to sea, where, as they gradually fall, they constitute rock masses which were excessively puzzling to the older geologists, having the mineral and physical constitution of igneous rocks to the eye, but often containing the remains of shells, or bones of quadrupeds, if on land; or fishes, corals, &c., similarly entombed at the bottom of the sea; whereas such remains would be utterly destroyed by a heat far less than that necessary for the production of the material composing the rock-mass. These submarine volcanic rocks are, however, so little popularly known that I need not dwell on them further than to point out that geologists recognise them as due to volcanic action, and that these volcanic ashes are found interlaminated in great beds through Snowdon and other large mountains in North Wales; for instance, in Russia, in North America, and in Canada, &c.; the term trap-ash being often applied by modern geologists to such igneous rocks deposited from suspension in water or from the air on land.

There is another igneous rock formed in nearly the same way, to which Italian geologists give the name of "*peperino*," and this is abundantly distributed over the country in the neighbourhood of active volcanoes. When an eruption takes place it is commonly accompanied by violent thunderstorms and heavy rains. Now, when we consider that the clouds of apparent smoke issuing from the craters are in reality great clouds of fine dusty materials, you can readily conceive that the raindrops falling through such dust would be coated over like pills, and come down somewhat in the shape and size of peas, forming a peculiar mass over the surface of the earth, to which, as I have said, the name of *peperino* is given, and having a strange analogy in many respects to the volcanic deposits occurring in the bed of the sea; inasmuch, for example, as this *peperino*, and the ashes brought down with it through the air, will very often appear stratified as if it had fallen through the water, and cover over field-mice and other small quadrupeds, birds, reptiles, &c., on the land, and other living creatures in small accumulations of fresh water on the surface, which in this way become embedded on the land in great quantities, although they certainly would have been utterly destroyed if the rock enclosing them had been at the time in a condition of igneous fusion.

The same thing pretty nearly occurred at Herculaneum and Pompeii, where a great overflow and outburst of volcanic mud, mingled with a large quantity of water as it came from the mouth of the volcano itself in the case of the one city, and showers of hot ashes in the other, entombed works of art and human bodies so rapidly, and preserved them so completely intact, from the first century of the Christian era down to our own times, that we can study their social peculiarities almost as perfectly as if they were of yesterday.

I mention these two kinds of igneous rocky material in the first instance because they are so unlike all the other and commoner kinds, although related in composition; and having so spoken of them, we may now consider the commoner kinds by themselves. In nearly all existing volcanoes, the commonest rock which is thrown out resembles the lump now in my hand, looking very much like a clinker from the furnace, or a large cinder. It is to this vesicular kind of stone that the term "lava" is generally applied. It is generally composed of two minerals—one, the commonest of all minerals in igneous rocks, felspar; the other, the black mineral augite, of which there are several specimens now lying before you. These two mineral materials may be readily melted in a blacksmith's forge at the heat melting ordinary pig-iron.

If this melted rock happens to flow over the surface of a level country, it almost invariably presents this appearance like petrified sponge, due to the great number of little holes in the stone caused by the air, steam, and other elastic vapours of various kinds given out with the melting stone, and expanding according to the shallowness of the quantity of stone flowing over the surface, forming large bubble-like holes when the pressure is small, but becoming small or imperceptible as the pressure increases with a greater thickness. But here before you is a much heavier stone, and perfectly compact, called "basalt," very unlike the vesicular lava in appearance, but which you would, on minute examination, find really identical in mineral composition. If the lava, instead of flowing over a flat plain, happened to get into a confined space, such as a narrow valley or river-course, where to a considerable depth it might be jammed together, you would find that in the lower part of such a mass the holes were not to be found, but that the stone became one of the most compact, toughest, and heaviest of rock masses with which we are acquainted—basalt; and at greater depths, producing greater pressure and slower cooling, the separate minerals would crystallise in separately recognisable portions, forming greenstone; the dense rock and the crystalline one and the vesicular lava being identical in composition; the differences being caused by pressure and the rate of cooling.

There are other great extremes due to exactly the same causes. If the cooling be much more rapid than that commonly producing lava, you get the *bimstein* of the German lithologists, the pumice-stone used by painters, excessively light, often floating in water, but still perfectly identical with the heavy rock masses with which we have been dealing, the only difference being the greater quantity of air cavities in it, surrounded by thin envelopes of rocky matter, caused by such a mass being thrown up rapidly in the air to a great height, and the consequent rapid expansion of the gases contained therein. Another extraordinary difference may be produced in the same way. I have in my hand what looks like a piece of common bottle-glass—ordinarily called "obsidian," or "volcanic glass"—of a dark greenish black colour, translucent on the edges, and with a conchoidal fracture, and so nearly resembling, as I said, black bottle-glass, that in Wales and some parts of England a very good trade has arisen from making bottles by melting a stone like what the Melbourne builders call bluestone, and cooling it suddenly so as to form this material. Yet it is perfectly the same in its composition as the vesicular lava, or pumice-stone, or basalt, or greenstone, which I have brought to show you, merely differing in the fact of having been still more suddenly cooled. Our bluestone is only another form of this rock-mass, having the same components—felspar and augite—and from which you pass insensibly to the hard black basalt, or if the cooling has been still slower, to another change, as in this stone I now show you, to which the name of "greenstone" is often applied, and where the constituent minerals separate themselves, the felspar forming little crystals by itself, and the augite or hornblende another series of crystals by itself; and in the different "bluestone" quarries about the town—as at Richmond, for instance—you may see all these varieties in unbroken masses of stone, some vesicular, some crystalline, and some dense and forming prismatic basaltic columns, like those of Staffa or the Giants' Causeway, on a small scale, and occasionally the glassy form.

If the cooling be moderately slow, it gives rise, under certain conditions in the same rock-material, to another set of rocks, of which porphyry is the type, in which some one of the materials forms large crystals, imbedded in a general mass composed of smaller crystals, or of a massive compact character, the material of the crystals being generally the felspar.

(*The lecturer here exhibited and explained a great variety of rocks in detail.*)

The general fact, then, established by investigation of volcanoes is, that if all these materials were mixed together and united in the interior of the earth, the many very different-looking igneous rocks would be formed, merely as the results of the different rates of cooling of one and the same stony mass. In all the older geological times the same variety of material has been certainly produced by the same cause—that is to say, by the rate of cooling from the state of fusion due to the intense interior heat; but besides this you find that some extraordinary generalisations present themselves, of great interest to the geologist, from the constitution of the igneous rocks formed at different periods of the earth's history. As a general rule, the very oldest igneous rocks present a considerable portion of the mineral quartz, but this quartz is excessively rare, or not present at all, in the more recent volcanic rocks flowing from active volcanoes.

Another mineral in the ancient igneous rocks is mica, which, like quartz, is also as a general rule very rare in the more recent ones. There are several ways of accounting for the different mineral composition of the igneous rocks of different ages, but let it be here borne in mind that the general subject of geological age cannot be measured by years or historic periods, but by relative periods; and the various geological epochs are generally indicated by reference to the various formations of stratified or sedimentary rocks succeeding each other in the order in which they were deposited in the sea of old time; it being obvious that a lower bed of rock if so deposited in the water must be older than another above it, and so on, each of these groups of beds having a name attached to it, as the silurian, the oolitic, the chalk, &c., represents the period of time occupied in its formation; and although people may differ as to the number of years any geological formation may have taken, there is no difference of opinion as to the *relative ages* referred to by the names of the formations.

The great series of geological beds of rock representing geological times are found as a general rule to rest on a basis of igneous rock, frequently that which is represented in a diagram before you as lying underneath all the bed-rocks, and to which the name of "*granite*" is given, in which the scaly mineral *mica* is excessively abundant, and the mineral quartz is also more abundant than in any other igneous rock whatever; these two, with felspar, are the principal components of granite.

Now, quartz and mica require an extremely intense heat to allow of their fusion and crystallisation, greater in fact than we can produce artificially, although of course they were thus originally fused.

According to the theory of Professor Abich, the materials of all these rocks which you see here depicted on these diagrams before you, were originally fused in one great melting mass; and when that mass in cooling first began to solidify, you can conceive that if all the mica, quartz, and felspar were in that seething mass, the first thing to solidify would be that which required the greatest heat to melt it—the quartz, then the mica, would solidify or crystallise first, as they are much less fusible than the others; and thus, from this infusibility of the two principal materials you would necessarily have granite as the first rock product of the cooling earth, with nearly all the quartz and nearly all the mica of the general mass, mixed with felspar, which although very fusible would probably be entangled with the others. This would explain why *quartz* and *mica* abound more in the ancient igneous rocks than in those of more recent formation resulting from the cooling of the remainder of the constituents. There is an interesting point to bear in mind here, that you should count the age of such igneous rocks in the opposite direction to that of those deposited on the bottom of the sea; the bedded rocks, as they are called, naturally becoming newer as you approach the surface; whereas it is obvious, according to the theory we are considering, that under a crust of granite first formed you would then have the materials for another crust, say of greenstone, in which there would be no quartz, but a great deal of felspar and hornblende; then, probably, still lower a series of porphyries and trachytes, with still more felspar, then basalt, and so on.

Professor Abich was the first to draw attention to the fact that the most modern of these rocks are excessively dense as compared with the older igneous deposits, and he points out that, after the granite had abstracted all the quartz and mica, leaving the ordinary constituents of the trap rocks, there would be a tendency in the melted rocks below to range them selves according to gravity, the heavier ones having a tendency to sink to the bottom, thus explaining the fact of the basalt rocks coming up to the surface of the earth after syenites, greenstones, and other nearly allied kinds, which we find more abundant in the older and middle periods of geology.

I have dwelt longer than I meant on this part of the subject, but it was necessary to do so before proceeding to speak, as I now will, on the characteristics of volcanoes.

When you examine existing volcanoes, you find that, although situate in very different localities, they differ but very little from any one type you may take as an example, and so nearly all the old instances of outbursts from below or within the earth of molten rocks would be found to have followed almost exactly the parallel characteristics of those of the present day.

Suppose, then, we consider the character of Mount Vesuvius, as here depicted in this long drawing, and which furnishes a very good example of the characteristic form of nearly all ordinary volcanic vents or craters, as generally formed.

Of the ancient crater of Vesuvius, the portion remaining, and called Monte Somma, is about 4000 feet high, having an irregular, broken, sharp-edged outline. The earlier physical character of this was a great circular valley, as you see here drawn, with a sharp serrated edge higher on one side than the other, but very precipitous, highly inclined on the outside and almost perpendicular inwardly. Below this extended a nearly level plain, on which a few flocks were fed; but there was no record of the igneous character of the mountain, nor even the slightest idea of its real nature, until the first century of the Christian era—not even a tradition of activity of any kind, until the occurrence of a very violent earthquake, which damaged several neighbouring cities; and then, after a succession of alarming shakings, a final one occurred in the month of August, A.D. 79, accompanied by a sudden explosion and bursting out of the whole of the central part of the valley, giving vent at once to an enormous shower of red-hot ashes, cinders, and *scoriæ*, as also of great streams of volcanic mud, entirely overwhelming the great cities of Pompeii and Herculaneum, the remains of which travellers can now examine at their leisure, the eruption preserving, at the same time that it buried them so completely as to form a level plain above the tops of their highest buildings.

From that time to the present the volcanoes of Italy have remained active. But the portion of Vesuvius now generally chosen for volcanic study is a small crater called *Monte Nuovo,* which arose in the year 1538 to a height of about 430 feet from the base of the original *Monte Somma,* and having a circumference of 8000 feet. It rose in about two days, and forms an inner cone in the centre of the great original one. I wish particularly to draw your attention to a general character of almost all volcanic craters in the world, represented in the drawings before you. You see the sides coming up with a steep slope, very nearly at that particular angle which is known as "the angle of rest," an angle you can imitate on the sea-shore or elsewhere by letting sand fall from your hand till it forms a small heap, the term being applied to the invariable degree of inclination that sand or other similar material would assume under such circumstances—the slope at which the grains would have no tendency to roll down to the lower part of the heap. Recognising this particular slope is of great importance in the recognition of the existence of volcanoes in various parts of the world, and is intimately connected with the formation of these volcanic cones.

When a section is made through a volcanic cone there is an appearance, as you see in the diagram, of beds sloping at the same angle or nearly so as the outside of the mountain, which beds are composed of layers of *peperino*, pumice stone, vesicular basalt, and other stony material, forming a series of deposits apparently sloping in every direction from the centre.

Baron Von Buch, in an elaborate treatise written by him on craters and their elevation, supposed these appearances to be indications of a series of horizontal beds thrust up in the centre by some great force acting from below that centre, and his term "crater of elevation" indicates his theory of the formation of volcanic craters by such influence.

But the real fact is, if you consider for a moment such an opening as this, in the middle of the plain, continually throwing up stones and ashes for ages, such ejected materials falling, as I instanced just now, like sand from the hand, the result must be a conical hill, with precisely the angle you find here, viz., the angle of rest. When you can get a cause in this way capable of producing a given effect, it is a safe plan to refer such effect to such cause, instead of to one of a less applicable kind.

When these cones are formed in this way, the occasional overflowing, during eruption, of the melting lavas rising in the crater, and flowing over in sheets from the top, will give alternate thicknesses of different kinds of rock, producing the different layers of stone, ashes, &c., observed; and all the best geologists are now agreed that Von Buch was in error in applying his theory of elevation to most craters.

Having drawn your attention to the peculiar angle of the side of a volcanic crater, I will now point out another characteristic of form of all existing active volcanoes.

Having mentioned that *Monte Somma* was much higher on one side than the other, so I may inform you that *Monte Nuovo* presents exactly the same appearance, the top of the crater being obliquely truncated and the lower side broken through, and thereon comes the explanation of why one side is lower than other. You will find, when you consider it, that in such a cone as this, with melted rock below seeking a vent, forced up through this long pipe (as it appears in the diagram) towards the summit, every addition to the height of the column enormously increases its bursting power, and when at last it becomes of such a height and power that it can be contained no longer, it bursts out on some one side or the other (usually that towards the general fall of the country); and whichever side it is that gives way, there is a great fracture inside, through which the current of melted rock is run out to the lower levels. You may recognise in many countries of the world, by these peculiarities of form, many hills of the nature of true volcanic cones, notwithstanding that they have long ceased to be active. There are in this colony many of them of a most perfect kind—the same outside slope, precipitous near the edge, and an oblique truncation of the hollow top of the cone (sometimes containing a small lake), and in the broken lower side you find traces of the overflowing current of melted rock which has produced that peculiar form. A beautifully perfect one, just like some of the extinct volcanoes of the Rhine or Auvergne, may be seen at "Jim Crow," or Mount Franklin, near the native station.

Studies of this kind led a number of French geologists, followed by Mr. Paulet Scrope, the famous English one, to the discovery of a great number of extinct volcanoes in Auvergne. In Central France, and Auvergne particularly, you find such appearances as these conical hills, with just this angle of rest, and formed of *scoriæ*, ashes, &c., and rising to a sharp obliquely truncated hollow upper part; and from the lower portion of the top edge a great stream of basalt, 20 or 30 miles in length, usually found running down to some low level. You can see the same sort of thing at Mount Franklin, or Jim Crow (as it used to be called), in this colony. You also see here the places in the broken lower summit from which the last flow of bluestone took place, with the flow marked by its having cleared its way apparently through the forest, and making its way with gum-tree forests on either side; the lava stream winding before you as far as eye can reach, but without a trace of vegetation on its course, and looking as fresh as if it was flowing yesterday, but which probably occurred in the later tertiary geological period of the old time.

Whenever the stream of lava, or a portion of it, gets into some cavity where it can cool more slowly, you often find the curious result of basaltic columns, of polygonal jointed prisms, as effect following the cause of such retarded cooling; as, for instance, in these illustrations before you of the celebrated Giants' Causeway and Fingal's Cave, in which you find a stone nearly identical to that (bluestone) which you find in many places going from Richmond to Ballarat in this country.

A curious experiment, illustrating this columnar formation on a small scale, has been made in England by Mr. Gregory Watt, and since repeated by others, by taking about seven hundredweight of common bluestone, there known as Derbyshire toadstone, and keeping it liquified in an iron-smelting furnace for eight days, then allowing it to cool slowly. He found the outside to be composed entirely of volcanic glass; then inside a mass resembling the rock to which the term pitch-stone is applied; then jasper; then a material nearly resembling basalt, without particular form; and then he found, a little within that, in the still more slowly cooling basalt, a tendency towards the formation of concretionary masses, producing, farther towards the centre, from their greater size, number, and mutual pressure, a series of prismatic columns, radiating from the central part towards the periphery, and jointed exactly as you see here represented in these delineations of the Giants' Causeway and Fingal's Cave. Dr. M'Culloch, in his work on the rocks of Scotland, pointed out that in some localities where these columnar jointed masses of basalt rotted or decomposed, the first parts to give way were the corners at the joints of the columns, this giving rise to an appearance, recognised by many writers, of a hollowed surface to some of the joints, with a convex rounded surface on others, as if they fitted into each other like cup-and-ball joints. This very acute observer pointed out, that if the corners came off from the joints, and this process continued, the inevitable result at last would be that the whole of the angularity would be lost, and you would have, in fact, a series of spherical, concretionary masses, just like those produced by the experiment we have referred to; but, originally, concentric surfaces, compacted into this appearance merely by lateral pressure. The experiment clearly showed how this is produced, and you may trace the same action in some of the moving streams from Vesuvius at this day, stone assuming that prismatic character generally at right angles to the plane of cooling.

Several most important characteristics of igneous action may be found in Mount Etna. In the diagram before us we have a portion of the interior of the great cone of Etna, with a section of a lesser cone, showing an appearance of stratification, which is the result of successive deposits of lava and ashes; and at various places you see great basalt buttresses standing out through fissures in the sides of the mountain, forming portions of what are solid walls of stone, nearly vertical, and traversing the scoriaceous beds in various directions, and terminating above in great sheets extending obliquely downwards over the side at the height it had attained at that time. These are known to geologists by the name of "*dykes*"—great vertical veins of igneous rocks, apparently cutting through the geological formation of various portions of the earth, but really intrusions of melted rock, usually from below, filling up great cracks or fissures in the earth, but sometimes cutting those channels to flow in. Nothing is more common in the coalfields of England than to find a basaltic or "trap dyke" thus cutting apparently through the coal-beds, and showing the geological action of fire on those beds in the same way that the same coal would show the action of fire in the retort of the gas-works—namely, by the distillation out of it of all the bituminous or gaseous constituents of the coal from near the dyke, where it is converted into cinders or coke; then, as you gradually recede from the dyke, you find that the mass of cinders, or clinkers, into which the coal is converted, becomes gradually changed into what is known as stone-coal, or anthracite, a kind of coal useful for many purposes, but remarkable for burning without flame, having no bituminous matter to produce it; and still farther off the ordinary character of bituminous coal is found unchanged. Similarly, dykes are often found traversing beds of dark, fossiliferous limestones, and changing them into snow-white, statuary marble, with a crystalline fracture like loaf-sugar, and destitute of petrifactions—changing them in the same way as great heat and pressure have been found to change such limestones experimentally. Thus, then, you find these appearances in Etna perfectly similar to those we know of in the oldest formations in the depths of the earth.

I now wish to draw your attention to a modification of the volcanic crater in the Sandwich Islands, as depicted here in the drawings before you, interesting from the difference presented from the ordinary forms I have already dwelt on.

It is obvious that for the production of active volcanoes you must have a large quantity of melted rock below the earth's surface, forcing up through craters, and spreading out in the different forms of rock I have briefly indicated to you; and in all volcanic and earthquake regions you must necessarily have this great molten subterranean supply. But very few of us could expect to see such a fearful sight as Dana made known in his description of the extremely different craters in the Sandwich Islands from those generally known.

In this drawing of the one of Kilauea you see a lateral cone at a much lower level than the great cone of the island to which it belongs, and acting as a sort of safety-valve. In the crater of Kilauea you find an enormous flat-edged opening in the crust of the earth (showing how very thin or insecure that crust on which we walk is), which seems merely an egg-shell-like covering over this vast area of seething fire below. In the middle of a great plain you see (as here depicted) a great hole, which is in reality several miles wide and long; looking down which you see the very unpleasant artistic prospect below of a lake of glowing, boiling rock, now rising to the brink so as almost to overflow, now sinking to a great depth. To give you some idea of the extent of this hole, it is suggested that if the whole city of New York were put down there it would be scarcely discerned. The whole of this is one vast boiling cauldron of seething rock, sometimes uprising near the edge, sometimes sinking for many feet, spurting out volumes of sulphur, steam, and other gaseous ebullitions; looking by daylight something like the pitch lake of Trinidad, but at night glowing of a dull red heat as far as the eye can reach.

The envelope of all this is almost a plain, with none of the acute angular, elevated, conical character of the ordinary craters; but there you see one of the very few instances that can be observed of a simple thin crust of earth, floating itself, resting insecurely on this enormous seething, melting mass of rock below, and which underlies so much of the earth on which we are dwelling in fancied security. Professor Dana describes how, while sitting on one spot in this plain, he saw the very place he had sat upon the night before crumbled in, melting immediately, and forming a portion of the fiery mass rising to the edge and then again subsiding.

This is, then, one of the very rare cases of a lateral vent connected with one about two and a half miles high, or more than twice the size of Etna, and which, with all the characteristics of the ordinary crater, occasionally gives outbursts of frightful volcanic violence, but seems to be continually relieved by the gentle boiling up and down below. It is certain that when this boiling flood rises to a certain height it flows out laterally under the sea, and thus gives enormous relief to the seething mass within.

But time warns me that I am unable to dwell longer on the direct application to geological subjects of the action of fire, although the subject is but half-touched; and I must, therefore, now, with thanks for your attention, conclude for the evening.

THE GEOLOGICAL ACTION OF WATER.

A LECTURE,

DELIVERED BY FREDERICK M'COY

(Professor of Natural Science in the University of Melbourne, Director of the National Museum, and one of the Technological Commissioners),

On 26th OCTOBER, 1871.

ON the last evening that I had the pleasure of addressing you on elementary geology, the subject I endeavoured to bring under your notice was that of the "Geological Action of Fire," and of the many ways in which geologists recognised its agency in forming the great mass of the earth—the various rock masses which under certain changes of conditions constitute not only the interior or central parts, but the whole of the earth with which geologists have to deal at the present time; and we saw how all these variously modified rocks, and all these accidents of surface, hills and valleys, depended mainly on various effects, both chemical and physical, clearly and exclusively due to igneous action.

I showed you, that if you supposed the whole earth to be originally a molten mass, composed of mineral materials comparatively few and simple, that according to degrees of fusibility, density, and other difference of circumstances, certain of these materials, or igneous rocks, would cool first, the result would be the actual mineral composition you find in nature, for the oldest and most inferior in position of the rocks you have to deal with.

I then showed you that all the investigations that had been made by geologists into the mineral composition of the rocks of the lower portion of the earth, and experiments made as to the various temperatures now perceptible at different depths in the earth's interior, all coincided in pointing out the fact of the original intense heat by which all the rocky materials of the earth had in the earliest times been fused, existing probably

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[*] This lecture is printed from the reporter's notes, as revised by Professor M'Coy.

at first as mere gaseous vapour, then condensing into a gigantic liquid drop, revolving on its axis as it now does. I then pointed out that if you had this liquid mass twirling round on such axis at the speed that we know the earth does so revolve, then in virtue of the molten condition of every part of the mass, it would, as a physical necessity of such rotation, assume the exact shape it now has—that is, somewhat like an orange, a little flattened at the poles, and bulging out at the equator. As philosophers are in the habit of referring effects to causes proved capable of producing them, all philosophers are now pretty well agreed on this elementary part of the subject to which I directed your attention in my last lecture.

I need not now refer again to the chemical and mineral nature of all the older rocks found in such conditions and places in the crust of the earth as would necessarily exhibit, if this theory of intense central heat were true, characters exclusively such as those produced by the liquefaction of the various minerals from heat, and not from solution in water; conditions in which all experimental observation agrees in showing that these igneous rocks do actually present.

Assuming then the theory correct of the original great heat and gradual cooling of the earth's crust, I proceeded to show you how it would necessarily contract in cooling and break up in various ways, and that in consequence of these ruptures various lines of mountains would be thrown up, the violence of the fractures displacing some portions of the crust upwards and others downwards, thus giving rise to the great physical features of the earth—the mountains of the land and the depths of the sea.

Having thus occupied your time on a former evening in considering the geological action of fire, I have now to invite your attention to the important geological actions of water.

To commence pretty much where I left off in the last lecture, you must consider that in the earliest time at which the earth assumed definite form and shape in space, it was still so hot that no water could exist on it, and that while you had a spherical form with a comparatively thin crust solid from cooling, there was another portion or envelope within that, in a liquid condition owing to the intense heat of the whole mass below the superficial crust; and then inside this liquid envelope you had the great central mass, increasing in its intense heat at a definite ascertained rate towards the centre, but nevertheless solid from the immense superincumbent pressure. When things were in this condition, you had granite forming the first crust, composed of quartz and mica, the two least fusible substances of the general melted mass, and therefore the first to solidify; and bearing in mind the necessity of the theory we have thus far elucidated, it would follow that the whole of the water we now know of in the ocean and elsewhere must have existed at this early period in a great atmosphere surrounding the earth, and formed of thin diffused clouds. The same cooling process which solidified the crust of the earth would extend further, space being intensely cold (much below zero of Fahrenheit), and such cooling going on with great rapidity, a portion of this atmospheric envelope would at last become so condensed as to be precipitated, and then down it would come in a great shower of rain. As soon as this first shower came down, it would boil from contact with the still extremely heated surface, and ascend again in vapour, but having had the effect of causing a still more rapid cooling of the surfaces on which it first fell, and then down would continue to come the water in still greater and increasing deluges.

Now, you must. bear in mind that the first form of the earth would be mathematically correct in the regular uniform shaping of the surface, affording no dips or hollows for the water to lie in, being what is in natural philosophy called a "spheroid of rotation;" and the consequence would be that, when these deluges came down, the water would at first evenly cover the whole surface, moistening it to a trifling depth. While the cooling process became by this means exceedingly accelerated on the surface, the inner fluid envelope we have before referred to would also in cooling shrink away from the superincumbent crust, which latter, being thus deprived of support, would at last break in with meridional lines of fracture running from pole to pole, and appearing sub-parallel to each other when viewed on the small scale. Thus as some portions of the crust fell in, forming great hollows in some places, while other portions being tilted up formed great hills in others, the waters till then uniformly distributed would rush into the deeps and hollows, and in the old words, "the waters would be gathered together, and the dry land would appear."

Thus far, then, the necessary preliminary for the simplest consideration of the geological action of water—by far the most important agent with which we are acquainted in altering the surface of the earth; which it does principally by degrading or wearing down the high lands, and distributing the worn portion in horizontal layers in the deep hollows of the ocean. These two actions may be separately considered, viz.:—1st, as to the degration; 2nd, the transport of the *debris*, or material worn away.

The first, or most simple, mode of the geological action of water, is that of clouds condensing on the mountain tops. You have first to consider the action of the sun heating the sea, and thus raising the water by evaporation from the surface of the sea; and this action of the sun in raising water from the surface of the earth is the simple foundation upon which must rest all we have to consider with regard to the geological action of water.

You will have then the sun raising the water by evaporation, and bringing the aqueous vapour to a greater height. But directly this vapour is made to rise much into space, the capacity for heat of the higher regions is so great that the vapour is cooled very quickly, and returned into the lower atmosphere in the shape of mist or watery rain; or if carried still higher into still colder regions, it is brought down again in the shape of hailstones. Now, take the case of this aqueous vapour impelled by air-currents, and passing along a low-lying region where the heat is sufficient to maintain in a vapoury condition a large quantity of water until it reaches a mountain side; the current forces it to turn upwards to get over this mountain top; and the air still appearing perfectly clear below, suddenly shows on the mountain top in the shape of cloud. The most common of appearances in every mountainous country, due to the greater capacity of the air in the higher region for heat, is this appearance of clouds resting on the mountain tops. For this reason it is that we have the simplest commencement of the geological action of water as a general rule on the tops of mountains, although it must not be forgotten that many mountain peaks pierce so high above the cloud-level, as it is termed, that they reach a region which is perfectly dry, owing to the intense cold permitting no vapour at all to mount there; but, taking the ordinary level of cloud condensation, you have the common condition known as Scotch mist, or more potent showers occurring almost perpetually on these elevated parts of the country.

These ridges or lines of mountains, sometimes called the backbone, and also the water-shed of a country, take the water from the atmosphere condensed into the ordinary liquid condition, which then by the force of gravity descends the sides of the water-sheds, and commences its geological work, which is in the first instance to decompose the superficial rocks at the top of the mountain, and this it does in different ways, partly chemical, and in all cases by physical or mechanical means, but whether by one or both operations the result is the same; invariably a tendency to disintegrate—in homely term, to rot away—that is, to produce a falling to pieces of all rock masses on which the water acts. You find that the first action even on the summits of the mountains is to denude them of all surface soil; and the waters then finding some particular channel, become more potent for grinding down material than before, forming beds of streams in the upper portions, gradually increasing to rivers below. As they go they continually wear away their channels, and still as they progress they add to their wearing powers enormously by carrying with them sand, pebbles, and other small portions of the rock masses worn away above, until the torrents are often of prodigious power, striking even the least observant eye. But geologists care little for these local instances of grandeur, and generally fix their attention more on the quiet, universal, and in reality much more powerful continuous action of this kind in every part of the world; a power having a definite relation to the velocity of the current, although an ordinary observer would scarcely be prepared to recognise the moving power of water in rivers at the ordinary rates; but striking examples are furnished at the mouths of some of the large rivers of the world, where the materials carried down form great triangular masses called deltas, from their form, resembling the Greek letter Δ—manifestly the result of the mud, sand, and shingle brought down to a level where the waters lose their transporting power from losing their velocity. These deltas have attracted the attention of all geological observers from early time, and I may refer here to some definite experiments made by Mr. Horner some thirty or forty years ago on the Rhine, at Bonn, on the exact transporting power of the river, which at that spot is some 1200 feet wide, 15 feet deep, and with a mean velocity of about 2½ miles an hour. His calculations gave as result the transport of 400 tons of material every hour, or about 8,000,000,000 of tons every year, nearly the whole of which is deposited in Holland, where the current loses its velocity, from the level nature of the country. This prepares you to consider the nature and extent of deltas formed at the mouths of greater rivers, such as the Ganges in India, the delta there being 200 miles long and 200 wide at the base, and covering 20,000 square miles of country, every atom of which has been carried down as mud in the water from the distant mountains in the interior.

I might multiply extraordinary examples of the definitely ascertained mechanical results produced by the greater rivers in various parts of the world, but general principles are all I have time to direct your attention to, so that I will pass on to fix your attention on the fact that the transporting power of a current of water increases enormously with its velocity; and this becomes a very interesting geological study.

When a geologist looks at any aqueous rock material which before solidifying must have merely presented the appearance of mud suspended in water, he knows that such fine material must have been deposited where no currents ran, probably at a depth in the ocean where no currents exist; and so, in looking at sandstone, or conglomerate containing sand, pebbles, &c., he knows that such a material must have been deposited where forcible currents existed, capable of moving such coarse portions; and carrying out this train of thought, the force of the current exhibits itself to the mind of the geologist in the size and density of particles in the deposits.

To take a few experimental examples of the actual transporting powers of different velocities, I may mention that common clay would be torn up easily by fresh water running at the rate of three inches per second, while it requires a velocity of six inches per second to carry fine sand such as that met with on the beach; eight inches per second will carry the coarser sand of the sandstone rocks, but it requires twelve inches per second to carry along even ordinarily fine gravel, twenty-four inches to carry round stones or pebbles two inches in diameter, and a swiftness of stream of thirty-six inches per second would be required for angular stones of the size of common road-metal.

The ordinary streams in hilly countries in flood-time frequently exceed this velocity, but when extraordinary floods occur masses of rock of enormously greater proportions, weighing even tons, are moved by currents of fresh water. To give a precise generalisation, the transporting power of moving water so augments with the quickness of the current, that in the language of the physicists it is said to increase "as the square of the velocity," a fact which will the more readily enable you to comprehend the great apparent increase of result in the case of deluges as compared to the comparatively small increase in the rate of velocity.

This remarkably potent action of fresh water in carrying along masses of stone arises from the fact of its great density as compared with air; and such being the case, it can be readily understood that sea-water, being from its saline constituents much denser than fresh, marine currents are consequently much the more powerful transports of rocky materials.

It becomes therefore necessary to apply a correction to the calculations I have mentioned as to transporting power, when considering materials deposited in sea-water; and in this way you find that very feeble currents indeed in the ocean are sufficient to account for the coarse texture of many sandstones and conglomerate rocks with which geologists have to deal.

The currents in the sea are of great importance to the geologist, not only (as in the case of what is known as the Gulf Stream, in the Atlantic) modifying the character of the climate, but even modifying the character of the animal and vegetable life to kinds which, were it not for such currents, could not exist in many definite localities. Thus, the immense current of the great Gulf Stream which I have just alluded to is the great transporter of the water and temperature of the tropics towards the north. Being nearly 1000 miles wide near St. Helena, and carrying on its vast surface a heated atmosphere of its own, it is reflected from the Gulf of Mexico so as to bring a portion of the temperature of the air and waters, as well as many of the floating seeds and fruits of the West India Islands, to the western coast of Ireland and Great Britain; and even as far north as to the Hebrides, four thousand miles off, portions of vessels wrecked in the West Indies have been carried by the current. The climatic effect of this on the British Isles is that, whereas by geographical position they should be surrounded with icebergs and icebound coasts; that the mountains should be covered with perpetual snow, and the valleys filled with glaciers; that only in the summer heats should the coasts be approachable; that scarcely any of the vegetables, and very few of the kinds of animals that now inhabit the isles, should be able to exist there—as is the case in the Island of South Georgias, of similar geographical position in the southern hemisphere: instead of all this there is a mild climate—snow only in the winter, no glaciers and no icebergs, and an abundance of the plants and animals of warmer latitudes; and this wonderful fact is due to the raising of the whole temperature of the country by the warm waters of the Gulf Stream. But yet glaciers and other evidences of ice have left their traces in various parts of the British Isles, indicating probably a time when the temperature was much lower, or the climate colder, than at present.

Another mode of the action of sea-water is in undermining and breaking down rocky coasts. Every shore presenting a rocky front to the sea is crumbling away, the materials being carried off and deposited on beaches at the angle of rest, or that slope at which grains of loose sand will arrange themselves for quiet rest—an angle offering a powerful barrier to the sea. The sand and broken detritus taken from every rocky coast is carried out and laid at that same angle on some other low sandy shore or beach; and so every rocky coast is going back and is encroached on by the sea, and every humble sandy shore is advancing, and driving the sea back from before it.

This action of the sea, combined with that of the streams from the tops of the mountains, bringing down mud, sand, and other gravelly detritus, tends to counteract all that igneous agencies have effected in raising the mountain ranges of the earth; the rocky cliffs will be laid low, the mountain ranges worn down, and both be deposited on the low-lying shores; and the consequence will be that in no long time—speaking geologically, of course—we shall have no more land; it will all go into the depths of the ocean, have a uniform covering of sea to a uniform depth over it, and we shall arrive at pretty much the condition in which we began, and there will be an end to our geology.

Few things are more interesting than the power which a little knowledge of scientific matters gives us of seeing wonders in the commonest objects before us, and if what I have said be true on a grand scale, it is also true on a small scale, if we cultivate the faculty of observing nature truthfully, taking care not to be deceived by thinking we understand the things themselves because we have learned to make use of the terms applied to them. Always make it a point in attempting to investigate a subject, to know definitely what is meant by every word you use and hear, and do not be deceived by mere terms or theories; but go plainly to ascertain the laws of nature for yourself, apply your reasoning powers to them; and every one of you may add something important to the stores of human knowledge, if you will only find the occasion to examine common things more accurately than others have had time or opportunity to do before you, and record your observations in perfectly simple and truthful language.

Nothing can be more marvellous than to look at the surface of the earth, and bearing in mind all this wearing away of that surface which we have been describing, to realise the fact that the present appearance of this our earth cannot have been, or be, of very long duration.

Go to Westmoreland, Cumberland, or any other lake district, and the idea will rest in your mind that the streams from these lakes are wearing away their channels, and that when these channels become more and more worn all the water must inevitably be let out from the lakes, and there will be an end of the great geographical features of the district.

To impress this point on your mind on a grand scale, let me invite your attention to this diagram of the Niagara River and Falls.

From Lake Erie you have the river coming down to another great lake below, Lake Ontario. On leaving Lake Erie it is a broad shallow stream, varying in width from one to three miles, and running a sluggish course through a great flat table-land—Canada on the one side, New York on the other—on a bed of silurian limestone, known as the Niagara Limestone, common also in Cumberland, Westmoreland, and in some parts of this country as well.

This table-land of nearly dead level ends abruptly at Queenstown, dropping to a lower level; and it is absolutely certain, from examination of the sides of the ravine, that originally the falls were at the point I now indicate to you on the diagram, where, as you see, an escarpment takes place, and formed a cascade such as we now see at the present actual falls.

In this escarpment you see that the upper half of the cliff is composed of hard dark grey marble, having under it a layer of shale, a soft muddy material, very evidently not so fit to bear the wear and tear of the river as the upper layer. Now the fall of water over the edge of the limestone at the escarpment wears away the soft rock below, and in doing so undermines a portion of the overhanging limestone; down that comes, and the consequence is that the Falls of Niagara have in this manner worked their way backwards for miles to their present position, where the retrograde movement is still acting in the same way. During the comparatively short period of observation of those living in the country, calculations have been carefully made as to the rate of this retrograde movement, a foot a year being the lowest, although many believe that three feet a-year would be a truer average. At this rate it would have taken only 35,000 years for the falls to have travelled from Queenstown to their present position; but lengthened period as that appears, you can well imagine the water still continuing to work back and back until the waters of Lake Erie are let out, and the whole face of the country changed by this incessant backward action and removal of the upper portions of the rock-bed to the lower levels, until these beautiful physical features of the landscapes, accidents of nature, destroy themselves by their own action.

Time is so short that I can scarcely touch on the more important matters I wished to draw your attention to, as showing the connection between the action of water and the grander geological features that geologists found much of their science upon; but I must draw your attention specially to the fact that, great as are the effects of ordinary currents at ordinary temperatures, both in the decomposition of land and in transporting it to lower levels, yet these effects are insignificant when compared with the increased powers developed by a reduction of temperature to a little below 32° of Fahrenheit, the freezing point of water. In all the cooler latitudes in which water freezes in the winter, you have this enormous and new power superadded. Water expands at the moment of freezing, a most curious and unusual property, which it possesses in common with but very few other bodies, the opposite being the rule. The heat of water may be reduced to forty degrees, and the water agrees with everything else by increasing in density as its temperature lowers to that point; but continuing to cool below forty degrees you suddenly find that it has a tendency to become lighter, and at 32°, or a little below, it suddenly expands, and increases by about 1-14th in bulk, and this it does with a power practically irresistable; so that you can well realise how wonderfully the degrading power of water is increased by the exercise in certain climates of this new natural property.

The ordinary slates covering our houses are not as a rule split by human means, for such an amount of labour would render them too costly. Take the instance of a slate-quarry in Wales. The masses of slate-rock are quarried, and left exposed with the edges upwards to the summer rains; the water is soaked up by them; and then, when the frost of winter comes, the water which has percolated through and amongst the *laminæ* of the slaty mass freezes, expands, and the whole mass opens out into so many leaves, like a book or fan; these *laminæ* being afterwards shaped into their due proportions for roofing and other purposes. What water does in this practically useful case it does invariably and everywhere in the cooler latitudes; so that in every valley the rains fall and drain into the crevices of the stony banks, and with the arrival of winter the rocks are torn asunder, and great sharp-edged and angular masses hurled around, as all who have travelled in such countries may have observed repeatedly. It is this expansion of the freezing water, wedging out great masses of rock from the mountain sides, which forms the main power in nature by which such masses are subjected the more easily to the comparatively weak action of the river currents that I referred to previously. The action of ice is enormous, not only for degrading but also for transporting; and this increase of power is also due to the expansion and consequent lightness of ice. The diminution of density is so great, that not only can enormous masses of frozen water float on the surface, but these can also support immense blocks of rock, and carry them thousands of miles over the ocean, moved by its currents from both polar regions to the warmer seas nearer the equator. You find in both hemispheres, towards the poles, these immense ice-islands, as depicted on the diagram now before you, coming regularly in spring and summer to the warmer seas, as far as the Azores in one hemisphere and the Cape of Good Hope in the other, and laden with these enormous rock-masses, of many tons in weight, having the peculiar character which the geologist recognises in them when found in all gravel and detritus of the "northern drift" deposits, as they are called, the peculiar character by which he at once recognises all these ice-borne rocks—viz., the edges and corners remaining sharp and unworn. As the icebergs melt in the warmer seas they frequently topple over, and then these immense blocks of stone are dropped to the bottom of the sea in this our present day, just as they were in the older geological times of the drift formations. The diagram before you illustrates some examples of these "erratic blocks" as they are termed, in the midst of large beds of fine sand and mud, deposited in all their angular character in those deep-sea beds in which no current could have travelled to roll them along; and also in rounded shingle-beds of boulders, or rounded water-worn stones, transported along the bottom by currents giving them a rounded, worn character, unlike that of the erratic blocks dropped amongst them.

A very curious circumstance connected with these "erratic blocks" is the fact that in Alpine countries you find them more commonly on the tops of the mountains than in the valleys or low plains. Let me instance to you the familiar example of what is known as the Three-rock Mountain, near Dublin, and which I draw roughly on the board before us. As you look from the city you distinctly see on the rounded top of the granite mountain, seven or eight miles off, three immense sharp-angled stones, which, on close inspection, prove to be of different material from the mountain itself on which they rest, and obviously come from some great distance. It becomes evident that at one time the surface of the sea must have been as high as the top of the mountain, or rather that the mountain must have been sunk below the level of the sea, so that the icebergs floating with these stones upon them there became stranded; and so with other submarine mountains on the shallows, over the upper points of which such stones have been deposited; and then when a whole country or continent was raised, there would remain the blocks on the tops of the mountains, and not in the valleys or plains, these latter in the submarine period being of course the deepest hollows of the ocean, which the icebergs would pass over unarrested.

The examination of the drift deposits in England and Scotland shows the geologist that at the latest of the geological periods immediately preceding human time, or even in human time itself, icebergs passed over those two countries in great number.

You doubtless know the configuration of the mountainous North of England tract of country joining England and Scotland, with its great mountains of limestone, and having towards the centre a low break, or north and south valley or depressed plain, with evidence of a great current having come from the north in the drift period, and rushed through this gap into the middle of England, and undoubtedly bringing great quantities of icebergs with it; for the northern sides of these limestone hills are so thickly covered over with unworn granite blocks that Dr. Buckland supposed they were *in situ*, and actually mapped out these hills as mountains of granite in his older plans; but subsequent research has shown them to be really mountains of limestone merely covered over with these granite and syenite masses, stranded on their higher parts; and what is more extraordinary still, every one of these masses shows traces in its mineral character of having come from mountains in Scotland, Sweden, or Norway, from which they were broken and to which they may be traced; while as you travel southward into England you find on the tops of the mountains the familiar North of England rocks; and so they all carry out the same story of ice-transporting action covering the land nearly to London itself with these obvious indications of its work.

In the same way you find geological evidence of the existence of ice and its mechanical action on this grand scale in many localities in Europe and America where such action no longer takes place, furnishing very conclusive evidence in its way of the existence during the formation of the drift deposits of what is known to geologists as "the glacial period," presenting the singular apparent anomaly of the particular localities in which these glacial formations make their appearance having been formerly visited with a very much colder climate than they now enjoy, in contradistinction to the general rule of evidence in all parts of the world in all geological times of the gradual cooling of the earth and climate as time progressed

An extraordinary evidence of the mechanical action of ice, besides that of transportation, is found in these regions. For example, nearly over the whole of Great Britain under the drift you find that the rocks coming to the surface appear as if planed by some vast planing machine, and not only so, but grooved, scratched, and scored in a nearly uniform north and south direction, and running for miles and miles in the same way as you would find at present produced on the beds of rivers or shallow seas by ice in which rocky masses had become entangled, marked with parallel lines not producible by any other means, and affording the most extraordinary evidence to the young geologist of the passing of ice with all these mineral masses entangled in it over the face of every familiar country of Europe, and the milder latitudes of North America.

From the failure of our time, I regret to find that I must leave untouched the subject of glaciers themselves, and the discussion of the "Glacial Period" of geologists.

THE EDUCATION OF ENGINEERS.

A LECTURE,

DELIVERED BY W. C. KERNOT,

On 28th SEPTEMBER, 1871.

THE subject I propose to consider to-night is a very important and difficult one, and I fear that within the short limit of an hour's lecture it will be impossible to render it justice. However, I shall endeavour to go into the matter as simply as possible, pointing out some of the more prominent evils in our present system of educating engineers, and suggesting means for their removal.

With regard to the importance of the profession of the engineer, I think no doubt can be entertained by any thinking person. The works of the engineer are found everywhere around us; wherever we go, and whatever we do, our comfort and safety depend upon him. Before our public lands can be rendered available for sale or settlement, the topographical engineer is needed to execute surveys extending over vast tracts of country, to mark out allotments, choose sites for townships, indicate lines of roads, and delineate the various features of the country. Then the road engineer is called in to open up practicable lines of communication, to bridge rivers, cross fathomless swamps, and supply a means whereby the produce of the land may reach the market, and the commodities of other countries find their way to the home of the settler. Until this be done, the most fertile district will remain practically useless to the community in general.

As population increases, and the resources of a locality become more fully developed, modes of locomotion and transport speedier than horse traction are demanded, and we find the engineer again at work, constructing railways.

His work does not end here. We soon require supplies of water, and the engineer is called upon to construct reservoirs, to lay down miles of pipes, to reticulate our towns, and bring the waters of mountain streamlets to our very doors.

Sewerage naturally follows water supply, and the engineer is required to construct drains and sewers, whereby our towns may be kept clean and dry, and all matters offensive to the senses or injurious to the public health removed at once to a distance from the dwellings of men.

Then our shipping needs harbours and docks for its reception, and these must be supplied, with various appliances for the purpose of loading and unloading vessels, and storing merchandise. Our rivers, too, will require improvement, and our towns and cultivated lands must be protected from floods. This involves the deepening of channels, the construction of embankments, and the execution of other works too numerous to mention.

Inland navigation gives further scope for the practice of engineering, and by the removal of obstructions, the construction of weirs and locks, the engineer causes streams which previously had conferred no appreciable benefits upon the districts through which they ran, to become most efficient highways for the conveyance of merchandise.

In localities where no suitable rivers exist, canals have to be made, and the construction of these necessitates the employment of no small amount of engineering skill.

The artificial lighting of our towns, the construction and management of gasworks, lies also within the domain of the engineer; and manufactures of all kinds—together with the operations involved in mining for gold, coal, iron, copper, and other minerals—continually require him to design and construct the various engines and machines necessary for their successful prosecution.

In fact, there is hardly any object, any commodity, anything we use, which does not in some way render us dependent upon the engineer; and this being so, it is clear that the importance of the profession is great indeed

Looked at from a monetary point of view, the engineering profession cannot fail to excite great interest when it is remembered that something like £20 per head for every man, woman, and child in this colony has already been invested in engineering works.

Suppose now, for one moment, that our engineers, through want of proper education, be not competent for the work they are called upon to perform, what will be the result? Our roads impassable, our railways a failure, our reservoirs bursting, our rivers overflowing their banks and destroying life and property, our manufactures languishing, the advancement of the country retarded, possibly even its solvency endangered.

Before discussing different systems of engineering education, it will perhaps be well to give an example indicating the nature of the engineer's work, and illustrating the various demands constantly made upon his judgment and skill.

Let us take a work of frequent occurrence, say a large bridge across some important river that has hitherto formed a bar to the traffic passing between two districts.

The first operation will be the collection of statistics. A careful investigation must be made as to the probable traffic across the projected bridge. Valuable data may be obtained from the Registrar-General's office, from local records, or from actual observation. The result of this calculation, viewed in connection with the estimated cost of the structure, will enable the engineer to judge whether the proposed work is likely, in a commercial sense, to pay.

The next step will be to determine the most suitable site for the bridge. The river must be examined, its floods observed, its banks surveyed, borings must be made in search of a good foundation; and quarries of good stone, of lime, and other material needed in the execution of the work, must be diligently sought.

The engineer will probably discover several promising sites, each one possessing some particular advantage over the others, and the ensuing process of weighing one recommendation against another, and arriving at a correct decision between various conflicting considerations, must necessarily be such as to tax to the utmost the greatest skill and the most carefully trained judgment.

The site fixed, the next step will be to design the structure, and first of all a choice must be made as to material. Stone, brick, iron, and timber each present certain advantages, and their relative cost and durability must be carefully considered before making a final selection.

Suppose the decision to be in favour of stone supports or "abutments," and an iron superstructure. In designing the abutments, an accurate knowledge of the supporting power of the substratum, and also of the horizontal pressure or thrust of the earthen embankment leading up to the bridge, will be needed. Should any error occur at this stage, the result will be either that a large quantity of valuable material will be wasted, or, on the other hand, the very existence of the structure may be imperilled by the lack of strength of its most vital parts.

The superstructure may consist either of a horizontal girder, so arranged as to impose a vertical pressure only on the abutments, or of an arch. In either case, the designer will first need to determine the greatest probable load the bridge will be required to sustain; then, by a somewhat complex mathematical investigation, he will discover the magnitude and direction of the various resulting stresses or forces acting upon all the different parts of the structure; and, finally, he must so arrange all the details as to obtain a sufficiency of strength with a minimum of material and workmanship. This work will demand for its successful completion—first, a thorough knowledge of the laws of force, as investigated by mathematicians; and, second, an equally thorough knowledge of the physical properties of the material, the process of its manufacture, the various forms in which it reaches the market, and the most convenient and efficient method of uniting together the integral portions of the structure.

The flooring or deck of the bridge, the handrail and other matters of minor importance, must lastly be arranged; and a judicious treatment of these details, though perhaps adding nothing to the stability of the structure, will greatly conduce to the comfort and convenience of travellers.

A carefully written description, called a specification, should accompany the plan. This is by no means an easy part of the work, as every omission or mistake is sure to turn up during the execution of the work, and become a fruitful source of annoyance and expense.

The operation of "taking out quantities" will next engage the attention of the engineer. By an intricate application of the science of mensuration, he will determine the number of cube yards of masonry, tons or pounds of ironwork, cube feet of timber, &c., &c.; and then his knowledge of the commercial value of various descriptions of material will enable him to estimate the total cost of the structure.

Tenders are now called for, and the contract for the execution of the work is let. The superintendence of the work immediately demands attention. Should the contractor prove an honourable man, anxious to fulfil his obligations thoroughly, all will go on smoothly; but if, on the other hand, he should be desirous only of his own emolument, and careless as to the quality of the work done, the position of the engineer will become most difficult. None but those who have actually been connected with the execution of important works can form an adequate idea of the numerous ingenious artifices employed by dishonest contractors in order to substitute inferior material and workmanship for that specified, and of the incessant vigilance requisite in order to detect and frustrate such attempts.

The work proceeds, and in due time is completed; but in almost every case small alterations are needed, errors in the specification are discovered and have to be rectified, and extras require to be authorised and paid for in a manner equitable both to the client and the contractor.

From this example—which is, I think, a fair one—it will be evident that the profession of civil engineer is most onerous, and makes very exacting demands upon the forethought, skill, judgment, and care of those who follow it.

The mechanical engineer usually finds an outlet for his skill in acting as contractor to the civil engineer for metal work, and as manufacturer of machinery. In this latter branch he has the great advantage of carrying out his own designs, and consequently knows nothing of the difficulty and anxiety of superintending contract work. Great demands, however, are made upon his ability and care in other directions. He needs extensive experience in the manipulation of metals, and must practise a most thorough system of keeping accounts, so that every portion of material used, and every hour of the workman's time, may be debited to the proper piece of work.

Although usually engaged in copying, with but slight modifications, well-known designs, he is not unfrequently called upon to devise novel contrivances demanding considerable inventive skill. Beside, a natural and laudable ambition will incite him to leave the beaten track, and improve upon the works of his predecessors; hence he will need considerable scientific knowledge to guide him in his investigations, to prevent him from wasting his time upon ideas which, being contrary to the established laws of nature, must necessarily fail, and to save him from the too common error of mistaking mere modifications for essential improvements.

The amount of skill and training exhibited by our engineers varies very much indeed. They may be divided into several great classes, not sharply defined, but passing by insensible gradation one into the other.

First—We have men of thorough education, both in science and actual work, understanding principle as well as detail, excellent in theory, unimpeachable in practice. These naturally take the highest place, and are without exception men of refinement and culture, upon whom for me to comment would be simply impertinence.

Second—A large class consisting of men possessing much practical skill, but unfortunately deficient in theoretical knowledge. So long as these follow in the footsteps and copy the works of their more scientific brethren, they do not fail to give satisfaction. But when they attempt to strike out in a new direction, and produce something original, they are in constant danger of falling into most serious errors through not properly comprehending scientific principles.

For many kinds of work such men are eminently adapted. For example, in road construction there is no need of accurate theoretic knowledge, but wide scope for the exercise of sound judgment, supplemented by that acquaintance with the properties of materials which long experience alone can give. In the supervision of works designed by abler men this class of engineers prove themselves very useful. Their great practical experience in the execution of work renders them most reliable and trustworthy ; while so long as they can understand an ordinary drawing and specification, and discriminate between good and bad work, their ignorance of the scientific principle upon which the efficiency of the structure or machine represented by the drawing depends is a matter of no consequence.

Third—We occasionally find gentlemen possessed merely of theoretic knowledge entering the engineering profession, and endeavouring to compete with other engineers. Their knowledge of principles is most thorough, but they lack practical acquaintance with matters of detail ; and lacking this, they fail. Most likely they could give an excellent description of the great Britannia bridge, but would hopelessly break down if engaged in the very ordinary task (to a practical man) of constructing a common log culvert.

The professional career of such is generally but short They retire discontented with themselves and with others ; and the further evil is that they bring scientific knowledge into disrepute with less educated men, who look upon them, and by implication upon all science, as a mere sham ; and so the great breach between theory and practice, instead of being bridged over, is widened.

Last of all, there is a class of men of whom, perhaps, the less said the better. They glory in the title of "practical," they hate theory, they despise science, knowledge of any sort they think beneath their notice, they consider they know everything and that wisdom will die with them; and no matter how great another engineer's attainments may be, if he happen to differ from them in the slightest particular, they put him down as a mere theorist, and declare him to know nothing at all about the matter.

These men are the bane of engineering work, and any one having such a man in the capacity of workman or contractor under him will know it to his cost. Nothing is right. The practical man knows everything, and the engineer knows nothing; the practical man buttonholes you to make you admit you are but a charlatan, an impostor, and will put forward the most preposterous ideas, utterly contrary to the firmly-established principles of science, forcing them down your throat as the result of his long experience, ten thousand times more valuable than any mere theory. I have known, have seen, these practical men, as no doubt many of my hearers have, the most ignorant but at same time conceited beings that can be imagined, and constantly making the most atrocious failures; but however gross their blunders, they never seem to see them, but continue to puff their own ability and waste the capital of their misguided clients.

The opinion that there is a necessary and inevitable discord between engineering theory and practice seems to have taken deep root in the minds of many men. "Very good in theory, but will not do in practice," is a phrase in constant use, and no one can come in contact with the majority of engineers without perceiving that they regard theory as utterly useless, and experience as the only reliable guide. We do not find astronomers behaving in this way—they do not inveigh against the law of gravitation, or hold up the parallelogram of forces to ridicule; on the contrary, they uniformly testify that the closest agreement exists between their theoretic calculations and actual observations; and if this be the case in astronomy, why not in engineering? The truth is, that in engineering, as well as astronomy, experience and theory are at one; and if there be any apparent contradiction, it is either because some error has been committed in the theoretical investigation, some essential term or factor omitted, or else the conclusions which we dignify with the name of experience are hasty and erroneous generalisations, liable to be greatly modified, if not completely reversed, by a more thorough examination of the facts of the case.

Perhaps you may remember an anecdote related by Mr. Ellery, in one of his lectures, of a captain of a vessel who experienced great difficulty in navigating his ship, owing to the chronometer having broken down. When asked why he did not verify his position by lunar observations, he replied that he tried two, one of which placed him in the centre of Sahara, and the second in some other equally impossible place, and that, therefore, he concluded that lunar observations were not of much account.

So with many engineers. They attempt to apply scientific principles which they have never thoroughly mastered, they omit some vital factor, and consequently their conclusions are vitiated; and then, like the captain with his lunar observations, they conclude that theory is an utterly unreliable guide. Very many instances of this particular error have come under my own observation.

The following example will serve to exhibit some of the evils flowing from the imperfect acquaintance with scientific principles commonly found amongst professional men. The security of life and property in a certain district depended upon the efficiency of a particular water channel. Four engineers were consulted as to its discharging power; two affirmed that it was ample, the other two were equally sure that it needed to be six or eight times as large. Each opinion was given after a most careful examination of the facts of the case, and the problem was one admitting, or rather requiring, a purely mathematical investigation. You will, I think, admit that there must have been great ignorance on one side or the other, especially when it is remembered that this subject has long ago been thoroughly discussed by scientific men.

Again, look at the number of absurd inventions, in prosecuting which men of great practical skill, excellent knowledge of detail, and capability of judging material and workmanship, have, for want of acquaintance with scientific principles, spent many years, or even their whole lives, in following visionary ideas which the slightest scientific examination would have exploded. Instances of the most egregious waste of time, skill, and money, for want of a very little accurate theory, are only too common in this colony as well as in the mother country.

Before leaving this part of my subject, allow me to read an extract from one of Professor Rankine's works, and to assure you that his view of the case is by no means exaggerated, and that examples of the evils to which he refers are to be found almost everywhere.

Rankine says—"It is on the practice of mechanics and engineering that the influence of the great fallacy is most conspicuous and most fatal. There is, assuredly, in Britain no deficiency of men distinguished by skill in judging of the quality of materials and work, and directing the operations of workmen—by that sort of skill, in fact, which is purely practical, and acquired by observation and experience in business. But of that scientifically-practical skill which produces the greatest effect with the least possible expenditure of material and work, the instances are comparatively rare. In too many cases we see the strength and stability, which ought to be given by the skilful arrangement of the parts of a structure, supplied by means of a clumsy massiveness, and of lavish expenditure of material, labour, and money; and the evil is increased by a perversion of the public taste, which causes works to be admired, not in proportion to their fitness for their purposes, or to the skill evinced in attaining that fitness, but in proportion to their size and cost.

"With respect to those works which from unscientific design give way during or immediately after their erection I shall say little, for with all their evils they add to our experimental knowledge, and convey a lesson, though a costly one. But a class of structures fraught with much greater evils exists in great abundance throughout the country, namely, those in which the faults of an unscientific design have been so far counteracted by massive strength, good materials, and careful workmanship, that a temporary stability has been produced, but which contain within themselves sources of weakness obvious to a scientific examination only, that must inevitably cause their destruction within a limited number of years.

"Another evil, and one of the worst, which arises from the separation of theoretical and practical knowledge, is the fact that a large number of persons possessed of an inventive turn of mind, and considerable talent in the manual operations of practical mechanics, are destitute of that knowledge of scientific principles which is requisite to prevent their being misled by their own ingenuity. Such men too often spend their money, waste their lives, and, it may be, lose their reason, in the vain pursuit of visionary inventions, of which a moderate amount of theoretical knowledge would be sufficient to demonstrate the fallacy; and for want of such knowledge many a man, who might have been a useful and happy member of society, becomes a being than whom it would be hard to find anything more miserable.

"The number of those unhappy persons, to judge from the patent lists and from some of the mechanical journals, must be much greater than is generally believed. The most absurd of all their delusions, that commonly called the perpetual motion—or, to speak more accurately, the inexhaustible source of power—is in various forms the subject of several patents in each year.

"The ill success of the projects of misdirected ingenuity has very naturally the effect of driving those men of practical skill who (though without scientific knowledge) possess prudence and common-sense to the opposite extreme of caution, and of inducing them to avoid all experiments, and confine themselves to the careful copying of existing successful structures and machines—a course which, although it avoids risk, would, if generally followed, stop the progress of all improvement."

The engineering profession is usually entered in one of two ways. Either the youth is articled for a term of years to an engineer in practice, or else he is placed at an engineering college where he attends lectures upon various scientific and professional subjects. At the close of his apprenticeship, or curriculum, he is supposed to be qualified to undertake work on his own responsibility. Each of these methods is, in my opinion, exceedingly defective, and I maintain that a judicious combination of the two is necessary in order to produce thoroughly competent engineers.

When a young man is articled to an engineer in practice, he is first employed in tracing or copying drawings, and other merely mechanical or routine work. After a time, if he show intelligence and aptitude, he is required to make working drawings of various structures and pieces of mechanism, these drawings being, in most instances, little more than fair copies of rough sketches supplied by the engineer. He is also afforded opportunities of inspecting works in progress. This constitutes the whole of his education. He cannot help learning *how* work is done, but he never learns *why* it is so done. The engineer invariably considers that the pupil receives full value for his premium in having the run of the office and access to the various drawings and specifications to be found there, and never for one moment dreams that it is any part of his duty to supply direct instruction in the principles of engineering science. The pupil, on the other hand, is well content with a system which imposes hardly any strain upon his intellect, and is only too apt to fall into the almost universal delusion that experience is everything, and theory of no consequence at all.

At this stage, I cannot but animadvert upon a practice which obtains with certain men professing to be engineers, but having no practice. Such persons open offices, insert magniloquent advertisements in the daily papers (a most unprofessional proceeding), and then endeavour to induce young men to pay high premiums for the privilege of becoming articled pupils. The unfortunate youths at first imagine in their ignorance that all is well, but before their apprenticeship is over they discover that they have been the victims of a most iniquitous deception, and that as far as engineering education is concerned they are no better off than when they commenced.

Gentlemen educated solely by being articled to an engineer almost invariably become members of that class of engineers who possess abundant practical knowledge, but make most egregious blunders in matters of a theoretic or scientific nature; excellent as they are in the execution of work, their designs are either mere copies and adaptations of existing structures, or, if they attempt anything novel and original, are characterised by a supreme disregard of the most firmly established scientific principles.

The second method of entering the profession is by passing through a course of systematic study at an engineering college. Those who adopt this route receive incalculable benefit from the mental discipline necessarily involved. They obtain a thorough insight into those fundamental principles which form the basis of all sound practice, they form orderly and logical habits of thought, but, unfortunately, they are very apt to despise small matters of detail and routine.

In my position of Lecturer on Engineering at the University of Melbourne, I have had many opportunities of observing this defect; many of the ablest among the students seem quite content with mastering the leading principles, and exhibit a marked indifference and disregard of detail. They thus are in great danger of becoming totally unfitted for attending to the minutiæ of everyday practice, and expose themselves to the ridicule of those who, with far less knowledge of principles, possess this indispensable acquaintance with detail. Great disappointment is not unfrequently felt by gentlemen who find, at the close of a curriculum extending over two or three years, that they still stand in need of many things in order to fit them for the practice of their profession. But it should be remembered that an apprenticeship extending over five or seven years is needed by many handicraft trades; and if an artisan's education requires so long a period, surely it is absurd to expect to obtain a complete grasp of a difficult profession in two, or even three, years. The University course cannot possibly do more than lay the foundation, upon which a superstructure of sound practical experience must afterward be raised, by means of long continued observation and study; and those who look upon their university studies in this light, and are careful to give both theoretic principles and practical details due attention, will not fail to confess that such a course is a most indispensable preliminary to the intelligent and progressive practice of engineering.

The judicious combination of practical and scientific training for a young engineer presents a problem of great difficulty; but, with all due deference to the opinions of the many able men who have thought and written upon this vexed question, I would venture to suggest the following course as affording, upon the whole, a tolerably satisfactory solution :—First, then, let the lad have a sound school education, suitable to the position in society he is expected to fill, and having, at the same time, a bias or leaning toward the pursuit which he is to follow. For example, his attention should be given to mathematical and scientific, rather than to classical or historical, studies. At the age of fifteen or sixteen he ought to be sufficiently advanced to pass such an examination as that for matriculation at the University of Melbourne. He should then devote at least one year to studies of a mathematical nature. Ample time must be given to algebra, Euclid, and plane trigonometry, and the greatest care should be taken in order to insure that the student may not only commit the principles of these various sciences to memory, but also thoroughly comprehend the trains of reasoning leading up to these various principles, and be able to apply them to the practical solution of problems. Great attention should be given to the working out of problems and exercises, and these ought to be carefully chosen, and should, in all cases, have a direct bearing upon the practice of engineering. This is a point of much importance. Very frequently the time of the student in mathematics is spent in the solution of problems, elegant no doubt in themselves, but of no practical value or interest whatsoever; while other problems, very nearly if not quite as well suited for the elucidation of the subject in hand, and of the greatest practical importance to the engineer, are totally neglected.

During this first year of study there should be no difficulty in mastering thoroughly algebra up to, but not including, the binomial theorem; plane trigonometry, as far as the solution of all the ordinary cases of right and oblique angled triangles; and the first six books of Euclid, together with exercises upon the various propositions. An agreeable relaxation from these somewhat severe studies may be found in spending a day, say, once a week in the practice of surveying.

The student might also spend a portion of his time in plotting the surveys, but I think it would be well for the present to make surveying and plotting secondary to algebra, Euclid, and trigonometry.

The first year's course satisfactorily completed, the student might be introduced into the office of an engineer in practice; here he should spend a portion, say about half, of his time in acquiring a practical knowledge of office routine, the other portion to be devoted to lectures upon the equilibrium and motion of rigid bodies and fluids. These subjects are of the utmost importance, and I do not hesitate to say that fully three-fourths of the errors and difficulties in which our practically educated engineers are so frequently involved are due to ignorance of these branches of inquiry. Here, as before, the student's ingenuity should be tested by an ample supply of problems and exercises, chosen as far as possible from actual engineering practice.

I am perfectly aware that the suggested division of the pupil's time between the office and the college would be looked upon with great disfavour by many engineers; but I am equally certain that, without some such arrangement, it would be extremely difficult for the student to obtain an adequate knowledge both of the theory and practice of engineering.

During the third year the greater part—say, three-fourths—of the student's time might be devoted to office work. He should now be competent to make original designs and working drawings for various minor engineering works, and also to perform the different operations of engineering field work, and in this way render himself of much value to his employer. The remainder of his time should be devoted to courses of lectures upon the strength of materials, the application of the principles of statics and kinetics to engineering structures and machines, and the principles to be observed in the designing of works. During the second and third years, lectures on chemistry and geology should be attended, as it is extremely desirable that every engineer should have a good general acquaintance with the principal facts of these sciences.

The study of higher algebra, of analytical geometry, and of differential and integral calculus, I do not regard as essential. Should the student, however, exhibit a taste for such subjects, let him by all means be encouraged to pursue them.

A thorough examination, extending over several days, and embracing all the subjects of the three years' course, would form an appropriate termination to the curriculum of lectures.

The engineer's education is not yet completed. It will be well for him now to spend from six to twelve months in the actual supervision of works in progress. He will thus gain much valuable practical experience, obtainable in no other way. He will be trained in judging of the quality of materials and workmanship, and will become acquainted with the management of contract work. At the close of a fourth year spent in this way a diploma or certificate of competency might be granted.

In order that the student may gain the greatest possible acquaintance with practice, it will not be sufficient for him merely to perform carefully such work as is specially committed to his charge. He ought also to take every opportunity of making himself acquainted with all designs, plans, schemes, and ideas in the office to which he is attached, and should master them completely, so as not only to know *how* any particular piece of work is to be executed, but also to comprehend the special reason or object of each detail. He should improve every opportunity of examining the practice of other engineers, and comparing it with that of his own chief; and by a careful attention to the literature of his profession, and especially such publications as *The Transactions of the Institute of Civil Engineers*, *The Engineer*, &c., should keep himself thoroughly conversant with all important professional questions of the day. With respect to this part of an engineer's education, Mr. Conybeare, who is a very high authority, speaks as follows:—"A thoroughly trained civil engineer's knowledge of practice, that is of examples of the application of scientific principles and formulæ to all cases of civil engineering, is not confined to the comparatively limited series of works which have come under his own personal observations; for during his pupilage he is generally allowed access, under restrictions, to the far more extended series of engineering cases presented by the records of the office in which he is placed, comprising the working drawings and specifications of all works executed by his chief during his extended professional career, including those which had been used for the construction of some hundreds of miles of actually executed railway. And he should extend this series of examples by a careful study of the literature of his profession, by analysing carefully, note-book in hand, all the published drawings and descriptions of approved examples of engineering that he can obtain access to, entering in his notebook, in each case, the more essential particulars of the example, such as its dimensions, material, principle of construction; also, whether the end in view in each particular case appeared to have been accomplished more or less economically and efficiently than in other cases, where, with a similar diagnosis, a different treatment had been adopted; noting, as far as possible, which were the particular points in each example most worthy imitation, and which, on the other hand, were better treated in some other example. By this process he will bring himself to a nearer knowledge of the one best way of attaining the particular end in view; for in every possible problem in construction there must be some one specific way of solving it that is better than any other; and by thus possessing himself of all that his predecessors had obtained, he will at least get as near the best way as they did, if he cannot, on the stepping-stones of their experience, rise to higher things in his own practice.

"The practical study of the published accounts of engineering works should not be restricted to English examples, for there is much that is worthy of imitation in the practice both of French and of American engineers. The former have always been superior to ourselves as theorists; and the extension of railways and other engineering works in France has of late years given them a more extended field for the application of science to actual practice, which their superior mathematical education has enabled them to turn to the best account. Their more recent works are consequently deserving of the closest study, and their published memoirs are generally models of methodic and scientific description.

"And American engineering is very highly suggestive. Necessity is the mother of invention, and the peculiar circumstances of America necessitated the execution of ways of internal communication of immense length, the frequent bridging of mighty rivers, the formation of quays, jetties, and graving docks, for loading, unloading, and docking the largest vessels—in fact, of all the appliances that modern commerce requires—at a mere fraction of the cost which in Europe is considered indispensable for works intended to fulfil the same purposes, and which scarcely fulfil them any better."

Taking Mr. Conybeare's view of the case, it is plain that the greatest possible advantage is to be gained by travelling to foreign parts, and examining the peculiarities of engineering practice in different lands, and under various circumstances. This, however, will, on account of the great expense involved, be an unattainable luxury to many. Fortunately, photography offers a not altogether inadequate substitute, by supplying the student with faithful representations of important works in all parts of the world, and I would strongly recommend young engineers to purchase and study such photographs as they may meet with. By this means their ideas will be enlarged, and their practice rendered more intelligent.

To sum up, then—theory and practice are the two pillars upon which all sound engineering work must be based. A man understanding theory, but deficient in practice, may have good general ideas, but will utterly fail in putting them into execution. A man of experience, but destitute of theory, will be able to carry out ordinary work in a satisfactory manner, but, should he leave the beaten track and attempt anything original, will assuredly fall into the grossest blunders for lack of scientific training. Those who have been well instructed in both branches will become intelligent and scientific engineers, while all others will, to the extent to which they are defective, be professionally crippled.

NOTE.

A plausible but most erroneous remark is frequently made by those who desire to disparage scientific studies, to the effect that the steam engine was originally invented, and that all great improvements in its construction have been made by purely practical men, and not by men of science.

The truth is, that the most approved steam engines of the present day differ but very little from those invented and constructed by James Watt; the principle is the same, and many of the details are the same; the main difference lies in a better proportioning of parts and a much higher finish. It is strange how small a field for improvement Watt left unexplored. And James Watt was not an engineer at all. He was by trade a mathematical-instrument maker, and was employed to repair and adjust certain philosophical apparatus belonging to the University of Glasgow. There he became intimate with several eminent men of science, under whose guidance he not only thoroughly mastered all the scientific principles bearing upon heat, evaporation, &c., that had then been demonstrated, but even launched out into a series of original investigations that would have preserved his memory had he never invented the steam engine.

Watt was a thorough man of science, and he treated the steam engine in such a thoroughly exhaustive and scientific manner that the combined ingenuity of three generations of engineers has failed to effect any radical improvement.

FERMENTATION.

A LECTURE,

DELIVERED BY WILLIAM JOHNSON,

President of the Pharmaceutical Society of Victoria,

On 5th OCTOBER, 1871.

It has been observed from time immemorial that certain bodies of a compound character—such as the juice of the grape, also grain flour—were, under certain circumstances, susceptible of a peculiar chemical change in their constitution, by which their general character became more or less altered. Nothing beyond the mere fact was, however, known to the ancients, or indeed moderns until a comparatively very recent date; no explanation offered, no cause assigned for the phenomena.

We read in "sacred writ" that our common ancestor, Noah, planted a vineyard, and, drinking of the wine, was made drunk. Evidently therefore the art of wine-making was known in the time of Noah, and as he is said to have planted a vineyard, he must have derived his knowledge and experience from a period still more remote: therefore the process must have been well known to the ancestors of Noah, even, perhaps, almost up to Adam. Fermentation, therefore, appears to have been one of the first chemical processes known to man. That its useful application to bread-making was known at a very remote period is also certain, for we are informed in Genesis that the Israelites practised the process when they were in bondage in Egypt, for it was during that time the feast of unleavened bread was ordained.

In wine-making all that is requisite is to place the juice of the grape into suitable vessels for a sufficient length of time and in a proper place, when fermentation sets in spontaneously, and continues to the end of the process. In bread-making and brewing it is necessary to add yeast, a substance composed of gluten, one of the constituents of grain in a certain state of decay or putrefaction, and abounding in a species of fungous growth of a very low type. By many this fungus is believed to be the direct cause of the fermentation; by others, however, this view of the case is much questioned, the cause being rather assigned to contact with a decomposing body. Possibly the truth may lie between these hypotheses; and, whilst allowing with Liebig and his followers that fermentation is excited by contact with a decaying nitrogenous body such as yeast, yet the cause of that decay itself may be, and most probably is due to the attacks of fungi upon it. Without fungi, then, there would be no decomposing gluten, and without decomposing gluten no fermentation.

You are, probably, most of you acquainted with the processes of bread-making and brewing. The latter has been recently ably elucidated in this Lecture Hall, by my friend Mr. Foord, and will therefore be only slightly alluded to by me, and even the process of bread-making need not detain us long. Most of you are doubtless aware that the baker takes flour, which he mixes up with more or less water, adding a certain proportion of brewers' yeast and salt; and when fermentation has fairly commenced, known by the rising and swelling of the mixture, the whole is well kneaded together; and after a while, when sufficiently risen and strong, the mass is cut up into suitable-sized portions, and placed in the oven to be baked into loaves. During the brief interval of time that has been consumed in the fermentation of the dough, some very intricate changes have ensued.

Wheaten flour may be described as composed, say, in 100 parts, of the following approximate proportions:—

Starch	60 to 72
Gluten	10 ,, 14
Sugar	4 ,, 8
Gum	3 ,, 5
Bran	1 ,, 2
Water	10 ,, 12

The causes of these variable proportions being referable to different varieties and to climate.

After the fermentation has proceeded some time, if the dough be examined it will be found to have suffered a loss of sweetness, arising from the destruction of the sugar contained in the original flour.

Before proceeding further it will be necessary to explain that there are several distinct kinds of sugar, which, though having a general family resemblance, yet differ from each other in certain important particulars. The first and most important one upon the list is ordinary sugar of the shops, obtained principally from the sugar-cane in various parts of the world; and also very largely in France from beetroot, and in America from the sugar-maple. This sugar also exists partially in honey, and, generally speaking, in most grains and seeds. Its composition is as follows:—

Carbon, 12 atoms ... ... = 72
Oxygen, 11 ,, ... = 88
Hydrogen, 11 ,, ... = 11
171

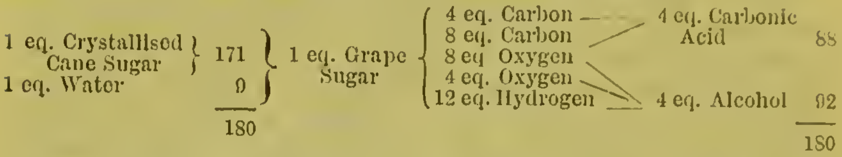
The next sugar upon the list is grape sugar or the sugar of fruits. This sugar is present in all acid fruits when ripe, and is in short the source of their sweetness. Weight for weight, it is, however, three times less sweet than cane-sugar. Chemically speaking, the only difference in the composition of cane and grape sugar is that the latter contains the elements of one equivalent of water more than the former. It is therefore—

Carbon, 12 ... ... = 72
Oxygen, 12 ... ... = 96
Hydrogen, 12 ... ... = 12
180

There are other sugars, samples of some of which may be found upon the table, including "milk sugar," the peculiar sweetening principle of milk; "manna," a peculiar sugar entirely distinct from ordinary sugar, and said to be not liable to fermentation; and eucalyptus sugar, found under some of our native gum-trees; also glycerrizine, the sweetening principle of licorice.

With most of these, however, we have at present nothing to do; our inquiries will be confined to the two first.

If cane sugar be required to be fermented, it must first be converted into grape sugar; this, as I have already explained, is easily accomplished by appropriating to itself the elements of one atom of water, as in the diagram, a step which it performs for itself, under the influence of the fermenting principle—viz., yeast. The process now goes on, and the following changes take place in the sugar:—



It will thus be seen that in manufacturing alcohol from ordinary sugar the weight of the product is about half that of the sugar employed, or about the same weight of proof spirit, about one-half of which is water.

In the ordinary process of bread-making precisely similar effects result from the action of the yeast; the sugar contained in the flour is converted into alcohol and carbonic acid, both of which become expelled during the process of baking, thus assisting the bread to rise and acquire that light, spongy appearance so much esteemed in good bread.

A good many years ago a company was started in London for the purpose of collecting and utilising the alcohol eliminated from baking bread, condensers being used for the purpose; but rival bakers, taking the alarm at the threatened injury to their businesses, diligently denounced the whole scheme, representing to their customers that such baked bread must be inferior to the ordinary kind, by virtue of having had all the "'whiskey' taken out of it!" and so successful were they that they eventually succeeded in stifling the novel enterprise. Since that time, I believe, no further attempts have been made to utilise the alcohol so formed, but it has been suffered to go to waste with the escaping carbonic acid.

In referring again to the list of products of the fermentation of sugar in the diagram, it will be observed that there has been no loss of material, the total amount of carbonic acid and alcohol produced equalling the weight of the sugar employed, and the question naturally suggests itself as to how the yeast acts so as to bring about the decomposition of the sugar; had any of the elements of the sugar been abstracted the process would be more intelligible. At present I am unable to give any precise explanation; the two bodies seem, as it were, not in any way to exchange particles. The sugar gives nothing to, and receives nothing from the yeast; yet by some peculiar sympathetic impulse, no sooner does sugar come in contact with the decaying gluten of the yeast than it becomes disturbed in its structure, and resolves itself into two bodies of simpler constitution and more stable character; for it is a general law in organic chemistry that when complex bodies change they do so into others of a simpler kind, the process being as it were a downward one, tending to reduce the substances changed more nearly to the comparative simplicity of the inorganic or mineral kingdom, from which they can be again elevated only by vegetable life under the restoring influence of the sun.

The products of ordinary fermentation, as the diagram shows, are alcohol and carbonic acid, the former remaining in the vat, the latter escaping. By passing the gas from the fermenting vat into lime-water it will be retained, and may be collected.

The alcohol remaining in the vat of fermented liquor imparts the stimulating and intoxicating property to it for which it is valued. Alcohol, though resembling water in appearance, differs physically in two points—it boils at a much lower temperature, and a gallon of it weighs 2 lbs. less than a gallon of water would. Hence, a liquor containing alcohol can have it readily separated by distillation. I have here a sample of liquor containing alcohol; I take a given quantity of it, for convenience sake say as much as will equal the bulk of 1000 grains of water; by now subjecting this to distillation I shall be quite sure all the alcohol will come over first; and by then weighing the product, and referring to certain tables, I shall ascertain precisely how much alcohol was contained in the liquor. This is the process always adopted to ascertain the strength of sweetened or mixed liquors. The process adopted by the Customs is to take what is termed a hydrometer, an instrument that partially sinks in water and spirit to a point proportionate to their gravity, the lighter and stronger the liquid the deeper the immersion, the degree being marked upon a scale attached.

We will now endeavour briefly to point out some of the properties of the products of fermentation.

Carbonic acid is, under ordinary conditions, an invisible gas, but may by pressure be liquified and even frozen. Being about half as heavy again as common air, it sinks in the latter, and may even be poured out of one vessel into another; and as it cannot support combustion, burning bodies are instantly extinguished when immersed in it.

It constitutes the "choke-damp" of miners, and is eliminated in vast quantities from volcanoes and certain mineral springs. It is the constituent which gives to lemonade, soda-water, bottled ale, and champagne their briskness, and is one of the final results of the combustion of fuels in open fires; also the matter into which a large proportion of the substances taken as food ultimately passes, being eliminated from the lungs in every expiratory breath.

Finally, carbonic acid is the main support and principal food of plants, being by them broken up into its constituents and reunited to other substances, such as nitrogen, hydrogen, phosphorus, and sulphur, ultimately reappearing in the form of grasses, fruits, trees, and flowers, for the use of the animal portion of organised creation, to give them food and life and enjoyment—to clothe the earth and fill it with beauty.

Alcohol, the other result of the process of ordinary fermentation, must now engage our attention. I have shown you how it may be separated from liquids containing it; let us now inquire into its properties. Here is a bottle containing some. A clear, colourless liquid, resembling water, very combustible, pleasant, and warm when drank; an agreeable perfume; very exhilarating; and in excess, intoxicating. When largely diluted it absorbs oxygen rapidly from the air, and becomes converted into acetic acid or vinegar. On the large scale this is effected by filling a vessel, having a false bottom, with some very porous material, such as beechwood chips, and pumping upon them very weak alcohol, and allowing it to percolate through the chips and out of the bottom of the cask, from which it is repeatedly returned. By this means, atmospheric air being freely admitted, oxygen is rapidly absorbed and vinegar produced.

As a lecture experiment platinum black may be taken instead of beechwood, as it still more rapidly causes the conversion of alcohol into acetic acid, readily shown by its action on litmus.

Alcohol is said to be the hydrate of a compound base termed ether, or one atom of ether combined with one atom of water; and under certain conditions, these bodies may be separated.

Ether is a remarkably volatile liquid, boiling at the temperature of the hand, and producing great cold upon the surface of the body it is leaving. Advantage has been taken of this property for the artificial production of ice, as in Harrison's patent, at present worked successfully in Victoria.

The following diagram shows the difference between the composition of alcohol and ether:—

Carbon, 4 atoms, weighing	24
Hydrogen, 5	5
Oxygen, 1	8
Equivalent of ether	37
Add to above one atom water	9
Alcohol	46

Ether is a base somewhat analogous in its chemical relations to the more fixed and durable alkalies and alkaline earths, and like them has the power of uniting with and neutralising acids producing characteristic compounds. We are thus introduced to a whole class of chemicals, many of them of a very interesting character. Its combination with hyponitrous acid is the origin of the "sweet spirits of nitre" of the shops, and is considered to resemble the flavour of apples. It is much used to impart flavour to the article known as imitation or artificial brandy.

With acetic acid it produces acetic ether, one of the ingredients also largely used to flavour artificial brandy. With butyric acid, one of the constituents of rancid butter and old cheese, it forms butyric ether, remarkable as proving to be identical with the peculiar flavouring principle of the pine-apple. If we distil alcohol with excess of sulphuric acid, we still further break it up and produce olefiant gas. The flavour of various wines are due to the presence of a variety of vegetable ethers, produced by the slow and long-continued action of the acids contained upon the alcohol, especially when warmed; hence the bouquet and general improvement which good wines acquire by being long kept. Hence also the rawness, want of fragrance and flavour, usually noticed in very new wines.

To Pasteur belongs the credit of having discovered that wines may be artificially matured—that is to say, that the various flavouring ingredients and ethers may be easily developed by keeping wines for a certain time at a temperature of about blood heat. This discovery has been very useful to wine-makers and storers availing themselves of it.

The ether which more especially predominates in good wine, and as a consequence in good brandy too, is termed œnanthic ether, and is a product of the action of tartaric acid upon alcohol in wine. It was originally discovered by Professor Liebig.

Most fermenting liquors contain, in addition to sugar, cellulose substances, such as the fibrous matters of grains and their skins, and, during the process of fermentation, especially if the temperature be somewhat high, and the solution free from acid, or still worse, alkaline, it has been found that the decomposition going on in the yeast and sugar becomes more or less communicated to them also. This need not surprise us, for when we reflect that these substances, however much they may differ in appearance, are composed of the same elements, as nearly as possible in the same proportions, it does not appear very wonderful that they should, under suitable conditions, be subject to the same sort of changes.

To those among you who may not be aware, I may as well state that there are in the vegetable world a number of very familiar substances so closely allied that chemists have termed them "isomeric"—that is to say, identical in composition, but different in form. Thus, in the class alluded to as concerned in fermentation, to which sugar belongs, we find gum, starch, cellulose (as in cotton wool), and cane and grape sugar; all these are as nearly as possible, if not absolutely identical in composition, and may indeed be often easily changed into one another. Thus, by long digestion in weak acid, starch becomes converted first into gum, and then into sugar; and if cotton wool or linen be subjected to the same treatment a sufficient length of time, the whole will disappear, and in their place a quantity of sugar, analogous to that found in fruits, will be formed.

In distilleries, where the object is to obtain the largest possible yield of alcohol from the saccharine materials, the process of fermentation is carried on to the uttermost, and not stopped as in brewing, before one-half of the sugar has been decomposed. Under these circumstances it is found that considerable quantities of cellulose become entangled in the peculiar decomposition of the ferments, and have imparted to them a similar decomposition. In this case, however, ordinary sugar alcohol is not produced, but instead we have a new body, possessing many of the physical properties of alcohol, but in other respects differing entirely. This new body is "fusel oil," so called from its somewhat insoluble character in water and oily appearance. When examined, fusel oil was found to have a somewhat similar relation to ordinary alcohol that the various sugars have to each other—members of the same family, having a family look, and partaking to a considerable extent of family peculiarities, but nevertheless distinct, and differing in character as much as brothers and sisters of ordinary human families usually do. True, the new body is a liquid, light and combustible, but boils at a heat exceeding that of alcohol. If we oxidise it we do not convert it into vinegar, but into a volatile acid possessing many of the leading qualities of acetic acid, yet altogether distinct. We produce valerianic acid, so called from it being always found among the class of plants called valerians, to which it imparts a peculiarly unpleasant smell. The root of the valerian officinalis particularly abounds in it, and is on that account used medicinally. A large class of valerianates are known, corresponding with the acetates, and like them always smelling of the acid. When we attempt to produce ethers from fusel oil, as in the corresponding alcohol series, still more startling discoveries are made, for when formed it has been found that the flavour of many fruits make their appearance; thus, with acetic acid an ether is formed, having the flavour in a highly concentrated degree of jargonelle pears, now much used to flavour sweetmeats. By varying the combinations several other flavouring essences have been produced having more or less similarity to well-known fruits. I have on the table essence of pine-apple, pear, black currant, cherry, apple, raspberry, all thus artificially prepared.

In the ordinary preparation of wines there are many circumstances which influence the result; thus, it has been found that if rapidly fermented, or at too high a temperature, a series of unpleasant ethers become formed in the wine, amongst which acetic ether is usually predominant, imparting that peculiar "mousey" flavour so often noticed in badly-made colonial wines.

There can be no question that the lower the temperature at which fermentation proceeds, and the more slowly it is effected, the better and more delicate will be the wine. It has even been found that the same grape-juice produces better wine when fermented in small vessels than when very large ones are used, the reason being that small bodies of liquid do not become so much heated as larger ones during fermentation, and also cool sooner afterwards. Even brewers have long been aware of this fact, and usually cool their fermenting liquors by means of spirals of cold water flowing through them.

The choicest Rhenish wines are made from grapes that grow in comparatively cold places, so that in point of fact they rarely ripen. Indeed it has been found that the best wines cannot be made in hot climates. In Europe, wines are often fortified and improved by boiling down the juice of the grape to a small quantity, and then mixing this concentrated syrupy extract with a portion of grape-juice not yet fermented; by this means greater body and sweetness become imparted to the mixed wine, and it loses a considerable proportion of the tartar so prevalent in many inferior wines. A reference to the chemical nature of tartar will explain this. This substance is a compound of tartaric acid and potash; it is not very soluble, requiring about 100 times its weight of cold water to dissolve it. Small as this quantity is, it becomes still less if alcohol be present; hence during the conversion of grape-sugar, in the process of fermentation, the wine becomes unable to retain the tartar in solution, and it becomes precipitated. An experiment will illustrate this.

My friend, Mr. Knight, who established a large vineyard at Riddell's Creek, informs me he can now make any kind almost of sweet liqueur wines, by previously in this manner concentrating his grape-juice. On one occasion, where the concentration had proceeded rather far, he was surprised to find the vessel in which it was stored nearly half-filled with crystals of tartar and other solid matters that had been deposited, the remainder of the liquor being a deliciously syrupy liquid, admirably adapted for fortifying and giving body to thinner varieties, and producing a wine less acid and better flavoured.

All fermenting liquids produce flavouring alcohols or fusel oils peculiar to themselves; and so persistent is the flavour thus often produced, that it cannot be got rid of. Whisky from malt, potato spirit, beetroot alcohol, arrack from rice, geneva from rye, and brandy from grapes, all have their peculiar flavours by which they may be distinguished; and by this means adulterations of the more expensive kinds may be detected. Simple evaporation upon the palm of the hand will often suffice. I have, in virtue of the difference existing in the various spirits, often detected the spurious Hamburgh wines, which used to be frequently imported here, and which were quite innocent of ever having seen a vineyard.

It has been found that in fermenting liquids, fusel oil is not produced, if certain aromatic substances, such as hops or cloves, be present, unless a very high temperature be used. Hence in well-made beer it ought not to be found. I have, however, often discovered it in colonial beers, especially some five years ago, when I undertook a series of examinations for the Royal Commission appointed to consider the Licensed Victuallers Act. Since this time, however, there have been numerous improvements in beer, and now, I believe, most of that sold, at any rate in Melbourne and suburbs and in the principal towns of Victoria, is good and wholesome.

Hops contain an aromatic volatile oil which may be separated by distillation from them. In the brewing of beer it is necessary to boil the hops. Now, it is quite possible to do this too much, so as to cause the evaporation and loss of oil of hops; hence when such wort comes to be fermented, it has lost much of the protecting ingredient that should prevent the formation of fusel oil. Thus it was that in years gone by many of the beers then made became thus contaminated with a disagreeable and unwholesome ingredient, recognised by connoisseurs as the "twang," so much complained of formerly in colonial beer. Since the period spoken of, however, our brewers have adopted a more rational process, and do not boil the hops so much as formerly.

Another cause for the occasional formation of fusel oil in beer is when the hop is only sparingly used, other bitters, such as quassia or gentian, being substituted.

Besides the ferments as yet spoken of, and so familiar to us in connection with bread, wines and beers, there exist in nature many other kinds of ferments; indeed their name is Legion.

All seeds owe their germination and development into plants to a species of fermentation first set up in them.

A seed—say, for example, a bean—is composed of three essential parts—viz., the embryo, the radicle, and the cotyledons. The embryo is the future stem, the radicle is the destined root, and the cotyledons are storehouses of provisions.

When placed in a suitable place where it can grow—that is, under the influence of moisture and warmth—some peculiar changes commence. The cotyledons, which are filled mostly with starch and albuminous substances, begin to change—a ferment has been generated; the ferment slowly but surely converts the whole of the contained starch into sugar, which, being soluble in water, can be absorbed by the infant plant for its nourishment, and it begins to grow; if we may be allowed the comparison, it represents the mother's breast-milk to the young suckling.

We have here a beautiful illustration of that ever-to-be-found beneficent forethought of the Creator that never ceases to provide for the wants and preservation of all His creatures, in the storing away in the cotyledons of the seed of food in an insoluble form, so as not to be dissolved and washed away by the rains of winter, and only slowly altered as the needs of the growing plant may require it.

The process of malting is founded upon fermentation. Barley thrown into a heap, and moistened, begins to germinate. A ferment called diastase is formed in the gluten, by virtue of which much of the starch is converted into dextrine and sugar, and the plant begins to grow. When it has arrived at the proper stage of maturity, the vitality is destroyed by heating the grain over a kiln erected for the purpose, and we have malt. Malt, then, is simply barley that has germinated. When this malt is again wetted in the mash-tun during the process of brewing, at a temperature not too high, the ferment proceeds to complete the conversion of the remaining dextrine, and the whole becomes converted into sugar.

I have here an infusion of malt, and I wish to show you with what facility this conversion of starch takes place when the two are mixed.

All kinds of seeds are obliged to germinate in a manner corresponding with the before-going, in order that they may grow and develope their peculiarities. If an ordinary bitter almond, for instance, be examined, it will be found to have no smell until it is mixed with water and fermentation excited in it, when the peculiar flavour of bitter almond oil becomes at once apparent.

Bitter almonds contain a principle called amygdalin, which may be extracted from them by boiling alcohol, and it is to the decomposition of this substance under the influence of the ferment peculiar to almonds, that the new bodies are formed.

If amygdalin be rubbed in a mortar with water by itself, no change takes place, but it cannot be mixed with the fleshy part of an ordinary almond, even a sweet almond, without suffering decomposition.

If an ordinary sweet almond be rubbed up with water in one mortar, and some amygdalin in another, no effect is produced till they are mixed, when the smell of almonds is at once apparent. Ordinary table mustard has similar properties. Black mustard seeds, from which the best mustard is made, contain a principle corresponding to amygdalin called sinapin, and when treated like the almond with water, the fleshy part of the seed at once sets up a fermentation, especially if warmed; and the result is that the sinapin, like the amygdalin, breaks up into several principles, among which the volatile oil of mustard, from its extreme pungency, is the most conspicuous. So long as the mustard is kept dry, no such change is produced.

Fermentation in the vegetable kingdom is much more common than may be supposed. It is, for instance, certain that to its influence the delicate perfumes arising from growing, and especially flowering plants, are to be referred. The (as yet) undeveloped bud contains the juices that upon the further opening of the flower are to commence to ferment by exposure to sunlight, warmth, and air; the results being, amongst other things, the sweet-smelling odours, and the honey which the busy bee so diligently collects.

If a handful of flowers—such as cowslip, violet, elder, or linden flowers—be placed in a fermenting liquor, the bouquet of the flower becomes communicated more strongly than could be effected by simply adding the distillate of one hundred times the amount, thus showing the marked effect of fermentation upon the juices of the flower; and it is said that advantage is often taken of this circumstance by vignerons to artificially impart some favourite bouquet to wines that only naturally are grown in some few favoured spots. It is said, on the authority of Liebig, that sage and rue are thus added, and thus some of the most celebrated wines imitated; but whilst, however, in the genuine product such flavour is permanent, the imitation is not so, but soon passes away. Brewers often take advantage of the same circumstance to impart a delicate hop flavour to beer by putting a few handfuls of hops into each cask, to be filled with new beer that has not ceased fermenting.

It is well known to farmers that all old, well-stacked hay is sweeter and more relished by horses than new hay; also, that it has more fragrance or aroma. The cause is, that after it is stacked a species of fermentation sets in, the mass warms, and sugar and some flavouring ingredients are produced.

The very familiar article, "tea," is not sold in the condition in which it is grown; if any person examines the leaves of the tea-trees to be found in our botanical gardens, he will be puzzled to trace any resemblance to ordinary tea, either in taste, smell, or colour. The peculiar properties of tea that render it so much esteemed do not exist in the growing plant, but are produced by subjecting the leaves to a peculiar fermentation during the process of drying.

The green leaf of tobacco, again, possesses none of the well-known properties of ordinary smoking tobacco; these are, as in tea, all developed by fermentation during the process of drying.

The ripening of fruits is the result of a fermentative process by which the starch so largely contained in all green fruits becomes converted into sugar.

In the animal economy the process of digestion is referable to a fermentative principle, "pepsine," present in the stomach, and the action of rennet upon milk in cheese-making is produced by the same substance, rennet being only the stomach of a calf cleaned and preserved. Dyspepsia is often only fermentation in the stomach. The difference between new and old cheese is the result of fermentation; indeed, a cheese that is quite new has no flavour whatever, consisting simply of curds and salt; but after it has been placed in the ripening-room a certain time, the new cheese warms, ferments, and develops the well-known flavour of cheese. The souring of milk is due to a species of ferment called lactic acid. Even hams and bacon undergo a peculiar ripening flavour by being kept, not existing in them when in the green state; and the longer they are kept the more pronounced does it become, and the more valuable the ham, so long as it is not allowed to become rancid. The Westphalian hams imported into England were remarkable examples of this extreme development of flavour without rancidity. Most of our colonial hams are little better than dried salt pork, and are singularly destitute of that rich flavour one was accustomed to find in Cumberland or Yorkshire hams. I am told that the climate has much to do with this, the best results being obtained in cold climates and very slow processes.

The changes which the best fresh butter suffers by keeping are induced in it principally by the fermentation of the milk not perfectly extracted from it, and it has been found that if required to be long kept, great precautions are necessary to effect the complete removal of the latter substance. Here, again, climate interferes, as it is much easier to separate milk perfectly from butter in cold than in warm climates; England, Ireland, and New Zealand will always therefore have advantages over Victoria in the perfecting of their dairy produce.

It is now well understood that many diseases which flesh is heir to are produced by various ferments. That terrible one known as diabetes is an instance in point. In this case a certain diseased organ of the body cannot come into contact with starch without immediately converting it into sugar; the two bodies excite each other to increased action; hence, to effect a cure or an alleviation of this malady, it is customary to recommend abstinence from all food containing starch; such fermentation being thus prevented in the body, the diseased organ is not excited, but has a chance, with treatment and care, of casting off the diseased condition, and becoming again healthy.

All contagious and infectious diseases are now referred to the action of ferments of similar kinds, communicated from one diseased individual to another previously in good health, and that in these cases the peculiar disease is always reproduced, with all its old symptoms and characters, to be again propagated, if opportunity offers, amongst fresh subjects.

We will now, before concluding, devote a few minutes to the causes of fermentation as now understood by philosophers.

To Schulze and Schwann the credit belongs of having first pointed out that if, before admitting air to a body capable of fermentation, that air be first passed through a red-hot tube, no fermentation was produced, and this led to the belief that the atmosphere contained germs or seeds which, becoming deposited upon suitable substances, set them fermenting by establishing a growth. Many close observers have since then, by means of the microscope, established the presence of such growths in fermenting bodies. Helmholtz went further, and showed that by separating a fermenting liquid from one not undergoing that change, by means of a membrane, such as a piece of bladder, porous enough to allow the fluid to pass through and become intermixed, but stopping the passage of solids, the fermentation process was not communicated through; therefore the cause of the development of fermentation in a suitable liquid must lie in something which cannot pass through membrane. He therefore naturally attributed it to some solid substances.

Since then Schroeder and Dusch ascertained that these germs might be separated from air by simply filtering it through cotton wool, but it was left to Professor Tyndall finally to clear up the point. He has demonstrated that ordinary air, to use the words of Professor Huxley, is no better than a sort of stirabout of excessively minute solid particles; that these particles are almost wholly destructible by heat, and that they are strained off, and the air rendered optically pure, by being passed through cotton wool.

To Pasteur, however, belongs the distinguished honour of having proved that germs really are filtered out by the cotton wool from air, for upon subjecting to microscopic investigation, he detected germs in the matter so filtered, and proved their power to excite fermentation when simply sown in a solution fit for their development.

Surgeons have long been aware of the danger of allowing air to gain admission into wounds, which would then fester and give rise to the most alarming symptoms, the germination of spores thus gaining admission being the cause. The beneficial effect of cotton wool as an external application to burns and scalds can now also be understood.

Pasteur not only ascertained that sperms were constantly floating about the air, but he also discovered that they abounded more in some places than in others, being plentiful in plains, and diminishing in number at great altitudes, as on the sides of mountains. I do not remember whether Pasteur carried on his observations at sea also, but the well-known length of time that meat keeps when hung up to the rigging of vessels may be due in some measure to the comparative absence of spores in sea air.

My own personal observations have shown to me that these germs are very numerous in forests, and on several occasions when I have taken a tent and camped for a few days near Fern-tree Gully, amongst the Dandenong Ranges, I have always found that meat very rapidly became putrid, unless salted; and, upon inquiry, I ascertained this to be the experience also of the settlers in the neighbourhood.

There can be no doubt that ordinary butchers' meat keeps longer when due regard has been paid to cleanliness, both in the abattoirs and in the places where it is subsequently stored.

It is also well understood that many diseases are largely propagated in consequence of the gross neglect of cleanliness amongst the inhabitants of certain districts, for every bit of organic dirt allowed to lie about and putrefy becomes the centre and source of millions of spores, ready to be diffused around, or, as very sensibly suggested by Dr. M'Crea, the Chief Medical Officer, perhaps carried by flies to fresh and even distant subjects. By no other means, indeed, could the somewhat recent appearance of small-pox in different places be accounted for.

Plants are also subject to the attacks of germs, and it cannot be doubted that smut in wheat, and the grape disease, and potato disease, are produced thereby.

It appears that insects are peculiarly liable to these attacks. In autumn, may often be seen upon windows dead flies, surrounded by a sort of white, woolly substance. Upon examination it has been found that the white substance consists of innumerable spores cast off in all directions by a minute fungus called "*empusa musa*," the spore-forming filaments of which stand out like a pile of velvet from the body of the fly, whilst the roots have taken complete possession of the fly's body.

The silkworm has long been known to be subject to a very fatal contagious and infectious disease called the "muscardine;" this disease is entirely due to a fungus. But of late years a still more serious disease has broken out amongst the silkworms, called the "pebrine," and has proved so destructive that it is estimated that the direct loss to France alone, in seventeen years, cannot be less than 50 millions sterling, to say nothing of the indirect loss caused by stoppage of looms and loss of employment.

In 1858 the gravity of the situation caused the French Academy of Sciences to appoint commissioners to devise some method of stopping, if possible, the plague. Some naturalists took one view and some another, till at last the French government despatched Pasteur to study it, which he did most perfectly and completely, the result being that the cause was again assigned to germs of a peculiar kind. As might indeed be imagined from his previous training, Pasteur was early led to suspect the true nature of the malady, and of devising a method of extirpating the disease, which has proved to be successful wherever it has been properly carried out.

I shall conclude this lecture by quoting the words of Professor Huxley, at the conclusion of his inaugural address at the meeting of the British Association, held at Liverpool, September 14th, 1870;—

"Looking back no further than ten years, it is possible to select three—1863, '64, and '69—in which the total number of deaths from scarlet fever alone amounted to 90,000; that is the return of killed, the maimed and disabled being left out of sight. Why, it is to be hoped that the list of killed in the present bloodiest of wars will not amount to more than this! But the facts which I have placed before you must leave the least sanguine without a doubt that the nature and the causes of this scourge will one day be as well understood as those of the pebrine are now, and that the long-suffered massacre of our innocents will come to an end.

"And thus mankind will have one more admonition that 'the people perish for lack of knowledge,' and that the alleviation of the miseries and the promotion of the welfare of men must be sought by those that will not lose their pains in that diligent, patient, loving study of all the multitudinous aspects of nature, the results of which constitute exact knowledge or science."

NITROGEN: ITS ECONOMY IN NATURE.

A LECTURE,

DELIVERED BY WILLIAM JOHNSON,

President of the Pharmaceutical Society of Victoria,

On 2nd NOVEMBER, 1871.

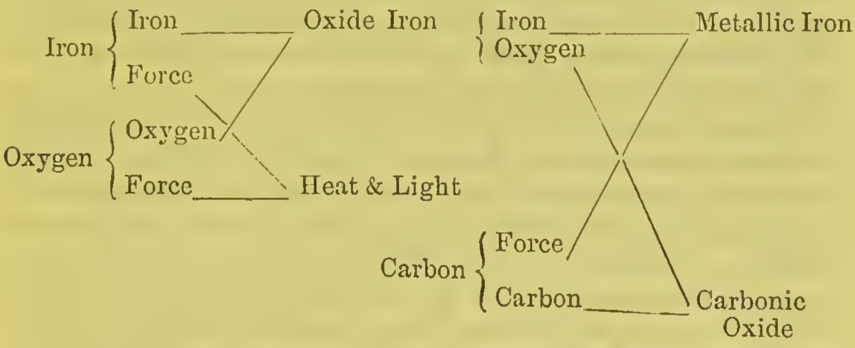
THE world around us has been ascertained to be built up of certain materials of diverse character called elements. Modern chemistry has increased the number of these bodies, from the comparatively few known to the ancients, to some 66 or 67 contained in the list before you. There are probably many more, but up to this time no further increase has been recorded. Of these substances the greatest number are metallic, generally found in combination with one or more of the other elements, and, with the exception of gold and platinum, rarely found free; and the same may be said of the other elements, for if we except oxygen, nitrogen, sulphur, and carbon, none of the rest are found uncombined in nature. Thus the great receptacle of chlorine is the sea, where it exists united to sodium to form common salt; hydrogen is associated principally with oxygen to form water; phosphorus with oxygen and lime to form bone earth; and so on with the rest, it being very rare to find any of these bodies free. There are, however, two very notable exceptions, nitrogen and oxygen; these two bodies, when simply mixed together in a free state in the proportion of about four to one, forming the great bulk of the air we breathe.

Nitrogen, the element we are called upon to study this evening, is under all ordinary circumstances a gas more remarkable when in a free state for its negative properties than for any other characteristic. It forms about four-fifths of ordinary air, the remainder being oxygen: At one time it was considered that nitrogen acted more as a diluent of oxygen than anything else in the atmosphere, and it was said that if it were not for the presence of this substance every combustible on the face of the earth would be consumed, and all life perish; for when oxygen gas in an unmixed state was examined, it was found to accelerate combustion to a most extraordinary extent, and bodies that burnt in air only slowly, or perhaps not at all, when placed in oxygen gas were found to do so with great rapidity.

There is no doubt that in the atmosphere nitrogen does act as a diluent of oxygen, but then this is only a part of its uses. Nitrogen may be prepared moderately pure by burning some substance in a confined space of atmospheric air that shall thus absorb the oxygen, such as a piece of phosphorus.

I before mentioned that we were conscious of the existence of some 66 elementary bodies; but though we call them simple substances and speak of them as elements, yet the truth must be confessed that not one of the so-called elements has been or can be shown to exist in an entirely independent state, or unassociated with an unknown principle which we term "force," a principle with which it enters into intimate union, and cannot be separated from except by substituting something else for it. For example, take the metal iron, one of the names on the list of elements: we find by experiment that it will unite with oxygen, that in fact it will rust by exposure; we also find that it may in pure oxygen be made to combine so rapidly as to ignite and give off heat and light. Now, the question suggests itself, whence came the heat and light? obviously they must have come from either the iron or the oxygen, or both; and this is exactly the point I want to press upon your attention. Heat and light exist in combination with all the known elementary bodies in certain fixed definite quantities that may be calculated. It has thus come to be understood that the quantity of heat given off by an elementary body in the act of combustion will be in exact proportion to the number of atoms burnt, without any reference to their weight. Thus, for example, an atom of iron is 28 times as heavy as an atom of hydrogen; but, as an atom of one body always contains the same amount of heat as an atom of another, be the weight what it may, it follows that 28 lbs. of iron will give off in burning no more heat than 1 lb. of hydrogen. The product of the combustion of iron will now be a compound of iron and oxygen, both of which elements have been deprived of the heat contained in each previous to their union with one another.

The notion that what are called elementary bodies are simple substances is therefore obviously incorrect; they are, in fact, definite compounds of some unknown substances with a force, the existence of which we recognise as heat and light, and which can only be separated from them by substituting some other combination, when the character of the substance becomes altered, nor can they ever be restored to their original condition unless this lost force is again given back to them. This may, however, be done in a variety of ways, of which the principal consists in directly mixing them with some other compound containing heat or "force," usually some of the compounds of carbon, as coal or charcoal, when the metal may have restored to it the forces it has lost, and made to reassume its original appearance. The following diagram illustrates this :—



The diagram explains generally what occurs in ordinary cases of union between elementary bodies, such union being usually accompanied by the elimination of force in some form or other, either as light, or heat, or electricity. That such forces do not necessarily depend upon a supply of oxygen, but may be equally produced by substituting other elements, can be shown by the energetic action of some of them, such as chlorine, which, when mixed with some of the metals, produce a sort of combustion. With antimony this is very marked.

Again, amongst the elements is phosphorus. By suitable contrivances this substance may be made to combine with chlorine and oxygen under water, and even under these circumstances we shall have heat and light given off, which the water is unable to quench.

I have here tubes containing metallic lead in a minute state of division, prepared by a chemical process. When the contents are allowed to come in contact with the oxygen of the air, the two enter into such rapid union that again we have heat and light expelled, and *inert* oxide of lead formed.

When oxygen and hydrogen unite, a great deal of force is disturbed, and water is generated. Water, then, is a compound of oxygen and hydrogen that have both been deprived of the latent forces existing in them when in a free state. I have here a flame of hydrogen; by its union with the oxygen of the air steam is produced, and when this is condensed, water.

As the equivalent or atomic value of hydrogen is only 1, and oxygen only 8, we might expect a great deal of force to be eliminated by the union of these gases, the two atoms, together weighing 9, containing previous to combination as much latent force as two equivalents of any other elements, in the case of iron weighing 56. I have here a mixture of oxygen and hydrogen, which I will cause to unite, and I will then show you what a deal of force, in this case eliminated in the form of heat, is evolved.

Water, the final result of the union of oxygen and hydrogen, is of course destitute of force. Nevertheless, these elements may again be separated from each other by restoring to one or both the forces originally contained in each before combustion. A piece of an oxidisable metal, such as iron, will slowly effect this; but with some of the alkaline metals, such as sodium and potassium, both of which contain force, the restoration of the hydrogen is effected with great violence, and even ignition, the hydrogen, as it is expelled again, taking fire in the air.

By substituting a current of electricity for the metals in this case, the forces may be restored to both, the oxygen and hydrogen being in this case obtained from the oxidation of certain plates of zinc contained in a galvanic battery.

It is useless to further multiply illustrations; enough has been shown to enable you to understand that what we call elements are in reality compounds of some unknown base (never yet in a single instance isolated) with a certain force, the effects of which are familiar to us under the forms of heat and light, or electricity, as the case may be. The combination of any of the elements is usually then accompanied by the evolution of the forces previously combined with them whilst in a free state. Usually, I say, for this is not always the case; for the element "nitrogen," which we have adopted for our lecture this evening, is a notable exception.

This body appears to have the power of uniting with and absorbing other elements, without causing the disengagement of their combined forces. In this respect no other body can compare with it, and on this account nitrogen becomes in nature one of the most important elements.

How nitrogen in the state in which it exists in the atmosphere first becomes united with other elements is not well understood, but it is known that when vegetable matters decay, nitrogen from the atmosphere is absorbed and ammonia formed, ammonia being a compound of nitrogen and hydrogen; and as ammonia is also the ultimate form that nitrogen invariably assumes in the natural decomposition of any bodies containing it—such as animal matters—there can be no doubt that the affinity of nitrogen and hydrogen must be very great.

Ammonia, then, is a substance constantly being generated around us, composed of fourteen parts of nitrogen to three parts of hydrogen; it is a gas having very remarkable properties; it is peculiarly pungent to the smell; may be readily detected in vessels containing it by the white cloud it produces with some acids. It is also a most powerful alkali, exceeding in neutralising power most other bases. It is also remarkable as assuming, under some circumstances, the properties of a true elementary body; and when united to one more atom of hydrogen, can even be made to amalgamate with mercury, exactly like a metallic body.

Ammonia is also remarkable as forming the type of a whole series of ammonias that are found in nature, and which have the same relation to each other, or family likeness, as the ethers and sugars I have referred to in my last lecture on "Fermentation." The substances known as "vegetable alkaloids," to which quinine, morphia, and strychnine belong, and which comprise such a vast body of interesting substances, are all "ammonias," brothers and sisters of the original ammonia we have been speaking of, and formed in vegetables by some mysterious process not understood.

Vegetable alkaloids appear to be ordinary ammonia, with one or more of the hydrogen elements replaced by groups of elements acting as only a single element, a circumstance very common in organic chemistry; hence the variety of such bodies is almost endless.

I just now remarked that under certain circumstances nitrogen had the power of absorbing other elements without necessarily expelling the latent forces contained. Thus, in the formation of nitrates, this takes place—nitrates are formed during the gradual decay of nitrogenised matters, such as animal refuse, under such circumstances that free access of air is admitted, and an admixture of lime or some other basic substance allowed to be present; under these conditions oxygen is absorbed by the nitrogen contained, and a nitrate of the base produced; this substance, when mixed with solution of carbonate potassium and filtered, gives on evaporation saltpetre or nitrate of potassium.

Nitrogen combines with oxygen in five different proportions—

$$NO_1 \qquad NO_2 \qquad NO_3 \qquad NO_4 \qquad NO_5$$

The first of these, or nitrous oxide—or laughing gas, as it has been called—is sometimes used as a mild anæsthetic in place of the more dangerous chloroform, chiefly by dentists. The second is produced by the action of nitric acid upon some metallic substance, or upon starch. The third, fourth, and fifth are formed from the second by spontaneous absorption of oxygen. But the most remarkable circumstance connected with this absorption of oxygen by nitrogen consists in the fact that no force, such as heat or light, are given off during the operation. The nitrogen has absorbed not only the oxygen, but all the forces existing in it when in a gaseous form. These forces it not only absorbs and retains, but even transfers to any salt into the constitution of which it may enter—for example, saltpetre. We can now, therefore, understand what it is that makes nitre or saltpetre so destructive. By way of contrast, let us take phosphorus: this substance also combines with oxygen, absorbing a similar amount of that element that nitrogen does; during the process, however, much light and heat are given off, and the final result is a comparatively inert substance—phosphoric acid, utterly destitute of all the properties that nitric acid is remarkable for, and forming a class of salts, "the phosphates," of very fixed nature, difficult to decompose, and resisting the highest temperatures, no latent force being in point of fact left in them. If I mix nitrate of potass with charcoal and sulphur, it gives me gunpowder; with phosphate of potass in place of nitrate, no effect whatever is produced; and yet the oxygen, the element admitted to be the active ingredient in gunpowder, is present in nearly equal quantity in both. It is obvious, therefore, that the condition of the oxygen must be widely different in the two cases. Here then is the explanation. The phosphorus and oxygen when they became united lost the whole of the latent forces contained in them, the resulting phosphoric acid being a substance, in consequence, absolutely destitute of contained force, therefore quite incapable of indicating any under any circumstances whatever. The nitrogen, on the other hand, not only absorbs the same quantity of oxygen that phosphorus does, but it does it quietly, without allowing any of the forces contained in it to escape or be lost. These forces exist in nitric acid and nitrates, much in the condition of a compressed spring, ready to leap out with destructive violence and suddenness when the balance of conditions by which they are held is disturbed. Hence, in gunpowder the force is to be referred to that original wondrous absorptive power of nitrogen of forces eventually transferred to the carbon and sulphur contained in gunpowder, and, finally, economically applied for propelling shot or blasting rock.

This property of nitrogen to absorb and retain force is very marked in many other instances besides gunpowder; thus, in gun-cotton—a substance that has of late years been used as a substitute for gunpowder, over which it has some advantages principally relating to weight and smoke produced in its use—it is the part played by the nitrogen present that gives it its character. As in gunpowder, here the nitrogen has imprisoned a large amount of oxygen, and all the forces originally held by both when in a gaseous form, and when from any cause the integrity of the compound is interfered with, their forces become released, and away they go. When gun-cotton is ignited in the air, very little light is given off on account of the gaseous nature of the products, and no ashes; but if some solid substances be mixed with it, so as to present a fixed residue for the heat produced to ignite, much light is formed. I have here gun-cotton, mixed with an earthy salt baryta, to supply a solid material that will not be dispersed as a gas. When this substance is ignited, so sudden and brilliant is the effect that I, some years ago, tried to get it introduced to some of our theatres, for the purpose of producing artificial lightning in place of the miserable failures at present made use of, but without success; for, though I succeeded in astonishing many theatrical managers by its marvellous effects, so conservative did I find them, and difficult to move from the old grooves they had been accustomed to, that I at length gave up the task.

There are many explosive compounds into which nitrogen enters and to which they owe their properties, but it will be sufficient simply to mention their names. Glonoine, or nitro-glycerine, is one of these; then we have fulminating silver and mercury, the latter being the material used for priming caps for guns; then come iodide and chloride of nitrogen, the most violently-dangerous substance known.

Professor Fownes thus describes this body:—"It is a yellow, oily-looking substance, that may be distilled at 160° Fahr., although the experiment is attended with great danger. Between 200° and 212° it explodes with the most fearful violence. Contact with almost any combustible matter, as oil or fat of any kind, determines the explosion at common temperature; a vessel of porcelain, glass, or even cast-iron, is broken to pieces, and a leaden cup receives a deep indentation. With phosphorus the explosion is peculiarly violent even under ordinary circumstances; a grain of the substance produces when exploded a report as loud as a gun. In making these experiments great caution is required, the operator covering his face with a strong wire-gauze mask. Dulong lost an eye and the use of a finger, and Sir H. Davy was wounded in the face, by the effects of its detonation." I am sure, under these circumstances, you will excuse me for not introducing this substance personally to your notice this evening, but will leave it to be sought out by the private student in places remote from danger.

Nitrogen combines with carbon, producing a very remarkable substance called cyanogen, which, under ordinary circumstances, is a gas that burns with a peach-coloured flame.

Cyanogen has all the properties of an element, and is capable of entering directly into combination with other elements, or of replacing them in compounds. With hydrogen it produces an acid substance, long well known under the name of prussic acid, the most sudden and deadly poison known. Fatal as an overdose of this substance always is, yet it exists in many fruits—such as almonds, peaches, apple pips, and the kernels of cherries and plums. Of course the quantity contained in these fruits is very small; but the fact is nevertheless very interesting, as showing that the most deadly poisons, if sufficiently diluted, may become harmless, and often indeed supply most valuable medicines. Thus, in small doses, prussic acid is one of the most powerful remedies for allaying excessive irritation of the stomach, as during incessant vomiting; also for relieving palpitation of the heart; indeed, its action is specifically directed to the heart in preference to other organs, and I may observe that it is by no means an uncommon circumstance for medicines or poisons to select some organ in preference. Thus, whilst prussic acid and digitalis affect the heart, strychnine takes the spine and nerves, arsenic the stomach and skin, morphia and alcohol the brain, belladonna the eye, and so on with others. Hence the poisons, when properly administered, become ofttimes most valuable medicines.

Cyanogen has a great affinity for iron, with which it combines in several distinct ways; that beautiful-looking yellow crystal now present upon the table is a compound of cyanogen, iron, and potassium. In this case the iron appears to have assumed a character altogether foreign to its nature; usually playing in compounds the part of a base, it in this instance plays the part of an acid, and in conjunction with the cyanogen can combine with other bases. With copper, for instance, ferrocyanide produces a deep red-brown precipitate of ferrocyanide of copper; with iron salts, an equally deep and beautiful blue, manufactured on a large scale under the name of Prussian blue. Amongst other uses to which this substance is applied is that of painting tea, of giving that beautiful bloom so pleasing to the eye, at one time thought (erroneously) to be communicated by drying the tea-leaves upon copper plates.

A good many years ago a large trade was done with China in Prussian blue, all of which found its way back amongst the tea imported from there. But at length the Chinese succeeded in finding out the process by which Prussian blue is made, having sent a countryman to Europe for that purpose, since which time they have made their own.

Prussian blue may be easily detected in tea, by simply washing with cold water, when it is removed.

It has long been a matter of wonder how steel was produced. Bars of iron, laid in charcoal and exposed to a red heat, gradually became impregnated with a certain amount of carbon, which somehow penetrated through them during the process of cremation, but how it was enabled to travel through a solid bar of iron could not be explained. Of late years, however, it has been pretty satisfactorily proved that cyanogen is the carbon-carrying agent concerned in the production of steel; hence to nitrogen we are again indebted for all our best articles of cutlery, springs, and steelware generally.

Cyanogen, combined with potassium, produces a salt very much used, on account of its solvent power of silver and gold salts, in electro-plating and gilding; a solution of silver in cyanide of potassium being always used for plating. Indeed so easy is the process, that if a copper coin, or old worn plated spoon or fork, be simply rubbed with a solution so prepared and a little chalk, it will become immediately coated with silver and made to look quite new again. Even brass may be, by similar means, plated upon iron; and in Birmingham it is said that thousands of tons of buttons and similar articles are now regularly coated with brass upon iron bases, thus proving very economical.

On the large scale cyanogen is produced by boiling down together, in large iron pans, a mixture of animal matter, such as the refuse from slaughter-houses and tanneries, with potass and scraps of iron, to dryness and low ignition; the charred mass being then washed with water yields a solution of yellow prussiate of potash, from which salt all the other cyanides are directly or indirectly formed. A patent was some time ago taken out for the manufacture of cyanide by the direct union of carbon and nitrogen, produced by passing air through ignited charcoal, but I am not aware whether that process is now carried on. This country presents very favourable opportunities for making cyanide, from the immense quantities of animal refuse obtainable from our boiling-down establishments and meat-preserving companies, and it has often been a matter of surprise that no enterprising individual has started the new industry.

Nitrogen is intimately associated with life, and is never absent from living vegetable or animal tissues; indeed the degree of vitality in a vegetable or animal substance may be approximately estimated by the nitrogen contained in it. In the lowest class of vegetables, such as the cryptogamia or sea-weeds, but little nitrogen is found, the quantity increasing as we progress upwards, being abundant in leaves and greatest of all in flowers and seeds; indeed, so general is this the case, that during fruition almost the whole of the nitrogen and vital force associated with it is not uncommonly removed from every other part of a plant and concentrated in the seeds, the stem then withering and drying up, as in wheat, and the agave Americana, or aloe tree, so common in this colony, and which, after growing a somewhat imposing and pretentious plant for seven years, then for the first time flowers, produces numerous seeds, and perishes.

Whilst wheat, oats, or barley are green, every part of the plant teems with nutriment, and if cut down in this state and dried, makes excellent hay; if, however, they be suffered to ripen, all this nutriment is withdrawn, the leaf and stem wither and grow yellow, a little straw being finally left, almost destitute of any nutritive properties whatever, all these having been removed to the ripening grain, destined as seed to produce new plants, or to be consumed as food by animals and man.

Vital force seems in all cases to be derived from the sun by vegetable aid, and to be stored by the latter in nitrogen compounds only, being afterwards transferred to the bodies of animals consuming them as food, and eventually becoming developed in the thousand different forms that constitute life. In the body these principles become gradually divested of the forces within them, becoming more and more reduced to substances of a simpler constitution. Hence it is that the much-used limb becomes harder than the part which has had rest, every motion being an act of life so far reducing the part where it is made. Hence beef from the leg of a cow will not be so tender as that removed from the rump or loin, because of the weight it has had to sustain, and the consequent loss of vital force and change into something inferior, and there can be no doubt that, weight for weight, such meat is really less nutritious than that cut from the best parts; it is therefore very doubtful whether such parts, unless very greatly cheaper, are really economical to use. One cause of the stringiness so general in Australian meat is the travelling the animals have undergone in search of water and food, incidental to a dry climate, every string thus produced representing original good meat, of much greater weight, that has lost its vital power in the process of exercise; indeed, much exercise of any kind is always injurious to meat, and tends to harden it and spoil it. For this reason it is not to be expected that meat produced in a dry climate will ever equal that supplied by well-watered plains, where cattle can eat and drink their fill with the least possible exertion to themselves, and where they may lay down and chew their cud, and rest in peace.

It is on account of the continued exercise that the legs of walking fowls are harder than their wings, whilst with birds that fly, as wild-fowl, the wings are harder than their legs. Even pigs that roam about, and for the most part find their own living, do not make good bacon, and most of our colonial hams are on this account very stringy and hard, and not to be for a moment compared with the delicious sty-fed pork of Cumberland or Yorkshire.

Nitrogen is the principal life-supporting element in the food of all animals. Food that is destitute of nitrogen—as starch, sugar, gum, and alcohol—are utterly unable to contribute anything towards the repair of that continual waste going on in every part of the body. True, these substances may contribute, and doubtless do, to the performance of many animal functions, such as sustaining temperature, and as nervous stimulants; but, inasmuch as they are destitute of nitrogen, they cannot increase muscle, or add anything to the tissues of the body; these are all nearly entirely made up from albuminous materials, originally derived from the vegetable world under the influence of sunshine and suitable other conditions. All plants are laboratories actively engaged in absorbing ammonia, carbonic acid, and water, and by the additional aid of a few mineral substances—as potash, phosphorus, sulphur, lime, magnesia, and iron, with a little silica—breaking them up into their constituents, and re-forming them into the most complex of all known compounds. A vegetable, therefore, may be viewed as containing the very highest and most complex principles of organic life. True, in animals very highly-organised principles are found, but these have in every instance been derived originally from the vegetable kingdom, and during the process of assimilation have suffered a diminution of elevation, being gradually reduced to a somewhat lower level. Gluten, the essential constituent of wheat, during the process of digestion and assimilation becomes modified into albumen and fibrin; no instance is known of albumen or fibrin producing gluten. Again, starch, the next important constituent of wheat, is easily converted into gum and sugar; no instance is known of gum or sugar being converted into starch. So it is in the animal economy: numbers of principles originally derived from the vegetable world are modified and altered into new ones, but the process is always one of destruction—a downward one, tending to reduce the substance to further and still greater simplicity, until it gets finally expelled from the body, expended and useless, and even reduced almost to the condition of a mineral substance.

I think gluten must be considered the highest and most complex form of organic creation; from the downward changes this substance undergoes when taken as food we successively obtain albumen and fibrin of blood, muscular fibre, chondrin (the cartilaginous principle of bones), gelatine, uric acid, and urea; every one of these changes being a downward one—the last, indeed, only half a stage removed from the mineral kingdom.

When an organic body has once been reduced to its primitive elements, there is only one way that it can be restored, viz., by vegetable life. It is not indeed possible to explain how this is by such means effected, but the result is palpable. Principles containing carbon, hydrogen, and oxygen are formed, and others again containing nitrogen; all vital power being contained in the latter. What this vital power is in the abstract we know not; it would, however, seem to be some higher force than heat, light, or electricity, though capable of being converted into any one of these at will. Thus by rapid exercise vital force is converted into heat; by the glow-worm, firefly, and sea animalculæ, into light; by the torpedo and gymnotus, into electricity, all at will; but whilst vital force may produce or be converted into any other force, there is no instance known of heat, light, or electricity producing vital force.

But it is necessary to draw to a close, not that the subject is in any way exhausted, but that the time is, and perhaps your patience also. I hope, however, I have been moderately successful in engaging your attention, whilst I have endeavoured, in a plain and simple manner, to bring before your notice a few of the important parts played by nitrogen in the economy of nature.

THE USES OF ART & DESIGN IN MANUFACTURE.

A LECTURE,

DELIVERED BY DENIS O'DONOVAN, ESQ.,

On 12th OCTOBER, 1871.

THE subject on which I have been invited to address you this evening—The Uses of Art and Design in Manufactures—is so extensive that, even if my condensing powers were far greater than they are, I could not hope to do more in one lecture than to bring before you merely some of its most prominent points. I must crave your indulgence therefore from the outset, if I should omit many things on which some of you might expect me to speak, and should deal with others more cursorily than their importance might seem to demand. It is a subject indeed so extensive that it embraces nearly all the long centuries with whose story we are acquainted, and nearly every object of human wants that the hand of man can produce. For there is scarcely an epoch from about the year 1800 B.C., which is the date of the earliest Egyptian ornament we know of, that does not furnish us with some lesson bearing on the relations of art and industry, and there is scarcely an object of daily use that may not be made "a thing of beauty," if it be only touched by the magic of graceful thought, and fashioned with elegant design.

Do not fear, however, that I am going to trouble you now with any dry and learned disquisition on the arts of the past. I shall not carry you back to look at the workmen of ancient Thebes, culling suggestions of beauty from "the flowery Nile," nor weary you with the old story of Greece, and Etruria, and Rome. I have no intention to occupy your time with the efforts of the middle ages to express their strong and deeply-implanted feelings according to principles learned from the broken columns and mouldering arches of a former era; and still less to dwell upon that return to the long-lost verities of antiquity which is described in art-history as the Renaissance. Suffice it for us to know that in the treasury of the past is a rich legacy of thought bequeathed by the master-minds of every country—a legacy of power which, if rightly used, will make us not slavish copyists, but the creators of a living art adapted to our wants, speaking the language of our time, and yet true to those principles consecrated by the sanction of ages. I hope the day will come when, in the Art Gallery of this noble institution, the inhabitants of Victoria will find a large portion of this legacy accumulated for them; and that these heir-looms will be chronologically and scientifically arranged, as they now are in every great public gallery, so as to give a distinct idea of the forms which art took under different circumstances, of its principles, its motives, and technical facts. When that is done, you will require no lecturer to tell you the use of art in manufacture, for you will find them so closely wedded whenever both were in a noble and flourishing condition, that it will be impossible for you to draw a line between them. So close and healthy is the connection between the art which we admire in a picture and the art which allies itself to material use, that, though we have different names for them, they are essentially but one and the same. There is a hierarchy, no doubt, in the different manifestations of talent, and even in the royal doings of genius; but there are the same laws for all, they all have a common origin, and they are all directed to the same end. The study of even the high art of the ancients is as necessary to the artisan who will never paint a picture, as that of Homer and Virgil to the literary student who will never write an epic. In both cases the mind is fortified and refined for whatever work it may be called upon to perform. It is to this art-culture of her working-classes that France owed the proud pre-eminence which her manufactures so long held in the markets of the world. In that country, besides the great galleries of Paris, whose preservation from the Vandal fury of the Communists was a source of rejoicing over the whole civilised world, there is scarcely a town that has not a museum and a church adorned with valuable pictures. Lithographs, busts, statuettes, are exposed for sale in every street, and are found in the homes of the humblest *ouvriers*. Art is everywhere, it meets the eye wherever one turns; and the consequence is, as has been proudly boasted, that sound criticism is as often heard in France from the lips of a peasant as from those of a prince. To this education of the taste and of the eye are due, in a great measure, the beauty of form and elegance of design which gained for French manufactures so high a position.

But the hand of the art-workman must also receive its art education. From those models consecrated by universal admiration the hand must learn to trace the graceful line, to wind into the subtle wavings of beauty, and to render with ease and promptness the forms which haunt the imagination. Happily, for some time great efforts have been put forth to spread this education of the hand amongst our working-classes. The Schools of Design lately established are doing much to popularise, not only a mere mechanical power of drawing, but that higher power which is derived from drawing properly directed. In the school attached to this institution it could hardly be otherwise, considering the collection of moulds and casts which it possesses, but I am happy to testify here that in all the schools with which I am acquainted I have witnessed an invariable desire to place the best models before the pupils. The education of the hand should however come as I have placed it, after that of the eye and the taste; for it is not generally until after one can appreciate better and see more than others, that the power to execute is widely or ardently coveted. I attribute, therefore, a great part of the success which has attended the establishment of these Schools of Design to the fact that a Gallery of Paintings and Casts had already existed for some years amongst us. For before you form schools, you must create the desire to enter them. You must first scatter the seeds of taste which seek for culture, and light up the love of beauty in the heart—that fruitful love which yearns not only to enjoy, but to produce. This, in fact, is the whole history of all true education of any kind, and this is the work which the National Gallery has been doing, as far as its resources would permit, amongst the inhabitants of Melbourne since it has been founded, and which it will continue to do with still greater effect, in proportion as its resources are wisely augmented.

But it may be said, "You surely do not mean us to give an art-education to our working-men. A little drawing may be useful, but all this dreaming and these high-flown ideas would only make them discontented with their station, and bring many of them to ruin." This is an objection I never hear without a feeling of indignation, which I avow it is sometimes difficult for me to repress. Art-training then is only good for gentlemen, and no one else! Be it so; but why should not a workman be also a gentleman? Even now, "many of them," says Ruskin, "are more gentlemen than your idle, useless people." Why, I ask, should they not have the opportunity to become more so, and to become all the better workmen for the change? For whatever gives real refinement to the worker will be found to give beauty to his work. The fact is—and it is a truth which has been long known in the world, though sternly and stubbornly repelled in England until now—that there is in reality nothing more humiliating in a trade than in the profession of a lawyer or a doctor, a man of letters or an artist. Raphael, who painted the "Transfiguration," and was the friend of cardinals and courtiers, was not ashamed to decorate the walls of churches with floriated designs; and Flaxman, who sculptured the "Archangel Michael contending with Satan," did not think it inconsistent with his dignity to furnish designs for the potter's clay and the workman in metal. A great artist once signed his pictures with pride "Francia the goldsmith." The masters of Michael Angelo and Leonardo da Vinci were goldsmiths, and to the same craft belonged Ghiberti, who beat out the bronze gates of the Baptistery of Florence. What we want now is workmen like to these, and believe me, if ever we are to have them, we must set our faces resolutely against the dismal doctrine of an age of darkness that art-knowledge or any other knowledge is not good for all men, be they who they may, and against that remnant of the ruder ages which stamps with degradation those who with cultivated minds and skilful hands are employed in ministering to the daily wants of life.

But if art in general is useful to the craftsman, that development of it which enables him to determine the most suitable form of every object he has to make, and to inscribe on it, with truth and beauty, all the facts of its material, its construction and its uses, must in particular be needful. This is what is called the art of design. It is not distinct from other art, being merely a special application of it, and can no more be taught by any fixed rules than the art of Phidias or of Raphael. A good designer must be born an artist, he must moreover be a man of careful observation and of much experience, and his taste must be cultivated by the happy influence of beautiful things. This is not to say he can be taught nothing. He can be helped to a more intimate communion with nature by learning those secrets which her ardent lovers have ravished from her in every age, and he can be taught those principles which are gathered from the accumulated observation of all those who have gone before him. The leading principles that have been hitherto established, and those about which alone authorities seem to be undivided, I shall now endeavour to lay before you in the shortest and simplest manner that I can. They will teach us better than anything else how useful, even how essential, is this art in almost every branch of manufacture.

All design is either constructive or ornamental. The first principle concerns both divisions. I give it in the words of Mr. Owen Jones—" Construction should be decorated, decoration should never be constructed;" that is to say, that ornament should be subordinate to construction, and should not be designed without reference to it; for a designer might produce an ornament most beautiful in itself, and yet show the grossest stupidity in its application.

With regard to constructive design considered separately, the most important and best-founded principle is the very simple and common-sense one, that an object must fitly answer the purpose for which it is intended. This beauty of fitness is nothing more than truth, without which art would be degraded to a systematic misrepresentation. Utility is the characteristic attribute of the manufactures of all the great eras of art. Indeed, it would be difficult to find a single example amongst articles of classical workmanship, of which it might be said that it was tasteful and elegant, without being particularly adapted to the especial object for which it was originated. Nor is this quite as simple a thing as might at first sight appear, for it is not enough that an object should be useful for its purpose; every portion of it should be designed with reference to the end in view—that a water-jug, for instance, should not only be made so as to hold water, but should have the handle so placed that the water can be taken in and poured out with the greatest ease.

Fitness is a quality demanded of ornamental design also. Perfect figure-drawing, or a beautiful landscape, would be out of place on a cup or platter; delicate tints and patterns of flowers would be inappropriate on the meaner kitchen utensils; and even the bellows that enters into the drawingroom becomes a monstrosity when it displays a moonlight view in Venice, or the balcony scene in *Romeo and Juliet*. This much may be said without entering into the lists for or against either of the two bodies of disputants who occupy the arena of ornamental art. Whether room decoration should be by flat patterns and dead colours, or should be by natural art such as that with which Tintoret adorned the Council Hall at Venice—whether a wall should be merely a background to the living figures in the room, or should be alive with lovely children playing amongst the vine-leaves, as Correggio would have made it—is a question which I need not, even if I were capable to do so, take upon myself to decide. Of one thing I feel certain: that decorative art, when wholly unconventional, may be dignified and beautiful, and wholly in its place in certain surroundings, and that in others it may be much less suitable than the inferior forms of a zigzag or a chequer. I am, therefore, no partisan of the extremists on either side of this dispute. The interiors of noble buildings—abodes of kings, and great edifices of the people—claim the highest efforts of art for their adornment; a spoon, or a snuff-box, or a coal-scuttle, are objects with whose uses high art can have no possible connection. Between the palace and the coal-box there are, however, various fields for decoration, and in these I think the artist must be left wholly to his sense of fitness and his taste. Taking it, then, for granted that conventionalism is often necessary in ornamental art, let me remark here that even good conventionalism can never be produced by a workman who has received no training in the higher departments of art. It has ever been so from Egyptian ornament to the purest mediæval of the thirteenth century; how conventional soever was any great school of decoration in the past, the knowledge of the human figure and the most skilled and perfect drawing are everywhere as distinctly to be traced as in the birds, and cherubs, and wreathed foliage of the cinquecento. The same holds good with regard to the drawing of plants, and fruit, and flowers. Even in conventionalism an accurate knowledge of their forms is essential, for every part of a plant or flower, if properly understood, each member of the vegetable organism, if properly delineated, is a veritable ornament; and when we consider there are about 100,000 species of plants, we may form some idea of the vastness of the treasury here awaiting the student. Nor is this all; the study of these delightful objects with which the great temple of nature is adorned, these "stars of the earth," and all the fair profusion of fruit and foliage that surround us, hold up for ever before us in their silent, fascinating beauty those great laws of repetition and alternation, on which much of the merit of good conventional design must always depend.

The conventional art finds its special place in the household—amongst the familiar and useful objects of our homes, but it would nevertheless be absurd to lay down the rule that all higher art should be excluded therefrom. In like manner, it may be said that the loftiest forms of art belong to the great public edifices, yet would it be an error to suppose that even here conventional art can find no place. The golden rule, therefore, is one of fitness. When decoration is beautiful and appropriate, it fulfils all the conditions of perfection. The statues of a majestic Gothic cathedral, as they ascend from the eye into the distance, and lose themselves in the shadows of its lofty arches, are rightly and properly conventionalised for the sake of effect, while the girdle of carved stalls and stone bas-reliefs around the choir is of the highest and most exquisite finish. In the same way, a teapot, ornamented with cherubs in high relief, or a carpet, resembling a menagerie marvellous with strange and savage creatures, are specimens of art falsely applied; but a sideboard, substantial, massive in shape, richly sombre in colour, may not unworthily receive the noble decoration of living forms; and I know no well-founded canon of taste that is violated when a cabinet is beautified with the most elegant pictorial composition, the most finished enrichments of sculpture, and the subtlest chromatic harmonies which the skill of the colourist can produce.

Another principle closely connected with this is that every article of manufacture should be not only fit for its use, and fitly ornamented, but by its design it should indicate the purpose to which it is applied, and should never be allowed to convey a false notion of that purpose. All the traps for the eye, in the shape of boxes that have the appearance of well-bound books, bells that look like inverted tulips, sideboards formed on the models of Grecian altars, and flower-stands treated as ruined castles, are false and vulgar in taste, thoroughly bad and irredeemably depraved in art.

And now, looking about for maxims for your guidance, I find the only remaining one about which there is no serious difference amongst authorities, is that concerning the fitness of design to the material to be used. "Every material (I give it in Sir Charles Eastlake's words) is restricted by the nature of its substance to certain conditions of form." Thus glass or any other brittle substance should not be made into the form of a pillar, the obvious idea of which is strength. Neither should glass be used wherever transparency is not desired. Feathers, or trees, or hair, should not be cut out of marble. Freestone is unfitted for work that requires minute elaboration, and cast iron should never be made to imitate wrought-iron ornament, or stone carving.

These, which are the fundamental principles of design, prove by their bare enunciation how essential is this art in the production of every object of daily use. Fine art produces beauty and elegance, design weds them to utility and fitness, and thus we see in a general way the uses in manufacture of art and design. But it will be well to go a step further than generalities. I shall, therefore, devote the remainder of the time I have to speak to you to compressing into as narrow a compass as possible some definite notions concerning the particular relations between art in its various developments and each of the principal manufactures that supply our ordinary wants.

The most important, perhaps, of all applications of art to handicraft, is that which takes place in the building of houses. In this land of our adoption, where it is the good fortune of so many to build, or create houses for themselves, this part of my subject assumes a special interest. Not only the character of the houses we are now building depends upon us, but that of the future homes of this country, and the street architecture of its cities will be influenced by our example for generations. Hitherto what we have done can hardly be much commended. A few buildings we have in Melbourne of exceptional merit, but in general it may be said that the least interesting town in all England is not more uninteresting than any of the great cities of Australia. All the ebullitions of uneducated taste in architecture, the vitiated copies of Italian buildings, the base vulgarities of design, the tawdry shop-fronts, the stuccoed terraces, and the thousand other abominations which have long been the reproach of the British isles, have been here ignorantly and slavishly reproduced. As in England, we have unfortunately no national taste in architecture, and hence no one would look for uniformity of purpose, singleness of style, or unity of character, such as we find in the cities of continental Europe; but it is surely not too much to expect that every man who has the means to build should have some idea of the difference between good and bad design, and a wholesome horror of all structural deceits; or failing this, that the professional men in whom he trusts should have a distinct and perfect notion of the essential principles of their art. Let me tell you, in a few words, what these principles are, that you may see how art and design will help you when you are to plan and ornament your homes, or when you are to have them planned and ornamented by others.

Above all things, the house must be adapted to the wants of the family who are to occupy it, and it must be suited to the climate in which it is built. A French *chateau* would hardly meet the domestic requirements of an ordinary Australian family, and the baronial hall or feudal castle of his Norman forefathers would certainly be an uncomfortable dwelling for an English country gentleman of the present day. For the habits which we have acquired in the island homes of our ancestors, the qualities perhaps most requisite in our houses are those of quiet comfort, seclusion, cheerfulness, and a certain air of importance in which there is no admixture of ostentation. If it be the house of a gentleman, he will in addition to all this require it to have a gentlemanly character, that good society may move within its walls smoothly and pleasantly, and that inside and outside it should be agreeable to a man of cultivated taste.

The consideration of climate is to some extent included in that of comfort. Shady balconies and deep verandahs, courtyards cooled with fountain freshness, and open turret and terraced roof from which to enjoy the evening breeze—all these things are conditions of comfort in our Victorian clime. And yet these are things, be it said in passing, which have hitherto not received the attention they deserve, our houses being more adapted to the gloom and chill of an English winter than to the perennial summer of this bright Australian land.

But climate has a relation to ornament as well as to comfort. The most refined enrichments, the most delicate carvings, which would appear spiritless if seen through a leaden atmosphere, will look well under the brilliant effects of our glowing skies; and the æsthetic merits of Renaissance design, which would in many cases be out of place amid the wind and rain of northern Europe, might be displayed to great advantage in this country of the sun.

One word more, and I shall have done with this portion of my subject. Size and costliness have no more essential connection with art, than the bulk of a man and the balance at his banker's have with his birth and breeding. Size is an accident, and taste costs nothing. Profusion of elaborate ornament, of course, cannot be had without a corresponding profusion of money; but elaborate ornament is not necessary to make a house which every man of taste will feel enjoyment in looking at. So well is this fact now understood, that it is acknowledged by most people that the homes of even the humblest class may and ought to be artistically designed. Hence it is that we now have philanthropists demanding that the house of the poor man should be tasteful, as well as healthful and commodious, on the principle which I have already enunciated to you, that beauty and use go together, and that the prettiest house will be the *best* house in every respect wherein a man can make his home and train his children. "The prettiest house," says the author of the *Moral Influences of the Dwelling*, "will be the healthiest, the most convenient, and the most comfortable; and I am persuaded that great moral results follow from people's houses being pretty as well as healthy."

When the house is built, the next manufactures that challenge our attention are those which clothe the naked walls, the hard floors, and the bare ceilings; and here, again, art comes to our aid, and tells us how this is best done. With regard to the walls, if pictures are to be hung upon them, the truest principles of art dictate that the real mural decoration should be subdued in tone and simple in pattern—that is, the ornament should be drawn in pure outline, and filled in with flat colour, and all appearance of relief should be strictly avoided. It will be necessary, moreover, that its general tone should give force and value to the objects in the room. Stencil-painting, which is much in vogue on the continent of Europe, is very suitable in this case, and a wall so decorated has an air of coolness which should be grateful in a climate such as ours.

Where pictures are not used, the mural ornament becomes more important. The eye rests in this case upon the wall alone, and demands for its gratification a greater play of line, and even, in some cases, roundness and effect of light and shade, for which, whatever Sir Charles Eastlake and Mr. Owen Jones may say, we have the authority of some of the greatest artists that ever lived. In this case, embossed papers, which appear like relievo leather-work, and have all the beauty of the old Moorish wall enrichments, are much to be commended; but what seems most agreeable to our climate, and what in reality is most artistic, is the adornment by frescoes. If we cannot have such works as those with which Bernardo Luini and the other great *frescanti* decorated the Brancacci Chapel, we may at least have the walls and ceilings of our humblest homes decorated as most Italian country houses are, with arabesques of various colours, painted in distemper—a simple and inexpensive kind of embellishment, that would render the rooms clean and light, and would, if the surface were smooth and polished, last literally for ages.

While on this subject, I may mention that it was once customary in Italy to decorate the exteriors of buildings as well as the interiors. In the days of Italian splendour and greatness, when her merchants were princes and her cities were thronged with gay cavaliers and noble ladies clad in the rich and picturesque costume of the cinquecento, you might have seen in Venice the façade of the Casa Martello covered with the beautiful work of Tintoret, the Palazzo Bolani decorated exteriorly by the pencil of Paul Veronese, and the Casa d'Oro attracting the eye of every passing gondolier by the graceful forms, the high thoughts, the captivating effects of colour, which Vesentini had lavished thereon. Or you might have admired, about the same period, as you passed through the streets of Cremona, the paintings of Campi and many more on the fronts of the leading houses; and in Brescia you would be charmed almost wherever you turned with the splendid decoration of Lattanzio Gambara, and a host of other distinguished artists. Suitable as such decoration would be in Melbourne, it is not too much to say that not one amongst us will live to see our streets adorned in a similar manner. We have neither the artists amongst us, nor the wealthy men of taste, from whom such things might be expected. But it is well, nevertheless, that we should be reminded from time to time of what has been done in other countries, that we may not be too easily satisfied with the humble efforts in the direction of art and art encouragement which we are making in Victoria, or which for many a year it may be possible for us to make.

Of tapestry as a wall-covering I need not say much. It has a highly rich and picturesque effect, but the costliness of all good fabrics of this description will perhaps for ever confine them to the narrow limits of palaces and churches. In most countries the introduction of paperhangings led to the decline of the manufacture of tapestry; but before that time it was a source of wealth and reputation in many states of Europe. The Gauls, with their quick artistic temperament, seem to have excelled in this manufacture even in the time of the Romans, when the red fabrics of Arras had already acquired a certain renown. In the tenth century we know that the monks of Saumur wove hangings decorated with flowers and animals; and about the same time we read of one of the Counts of Poitiers offering Robert, King of France, for his assistance in an expedition, a sum of money and a hundred pieces of the tapestry, for which Poitiers was then celebrated. Later on we find Francis I. making tapestry a state manufacture, and Primaticcio furnishing the designs. Henry II. and Henry IV. set up new establishments, and Philibert Delorme and Jean Gobelin are names that have become illustrious under the patronage of the French crown. During this time Italy and Flanders had become equally famous for their tapestries; in Flanders particularly the productions of this kind were of wonderful beauty and perfection. Oudenarde, Brussels, and Arras, will be for ever celebrated in the history of this manufacture. Among the ancient glories of which Arras still preserves a proud remembrance, are a series of tapestries which Robert of Flanders gave to Bajazet as a portion of the ransom for his son, and the ten pieces worked from the designs of Raphael, as a present from the French King to Leo X. In the 15th century the manufacture declined in Italy, and the last piece of Flemish tapestry was made at Brussels in 1781. France alone, of all nations, continues to be renowned for its hangings. The grand design, the perfect execution, the exquisite beauty of the great works of art, which have been produced by the Gobelins manufactory in modern times, are too well known to require any commendation from me.

The list of methods in which art is used in mural decoration would be incomplete without some mention of the sumptuous mosaics which adorn the ancient churches of Italy with their variegated hues and crystalline brilliancy, which repeat the magic of Raphael and Dominichino in St. Peter's, and which for nearly a thousand years—from the fourth century to the revival of tempera—was almost the only sort of wall embellishment employed. Well might Ghirlandajo say that this is the only painting for eternity. There are mosaics in and near Rome of the fourth or fifth century—as that of St. Constanza, which is of the fourth—in almost perfect preservation; and those of the sixth century, in the church of San Vitale, at Ravenna, are as fresh as they were thirteen hundred years ago. In the famous studio of the Vatican this beautiful art is in our day carried to a perfection unknown to the ancients. The number of enamels of different tints and hues preserved there amounts to no less than 10,000, and many of the large copies in St. Peter's have occupied from twelve to twenty years in their execution. The Florentine mosaics are also famous. The work of this kind, with which the walls of the chapel of the Medici at Florence are so lavishly decorated, is composed of such costly materials as agates, jaspers, lapis lazuli, and the like. In Venice, glass mosaics are made, specimens of which are now to be found in many of the public structures in England, where they are much admired for the old hereditary art, of which even the hated power of the *Tedeschi* never wholly robbed the "Bride of the Sea."

Turning from the walls and ceiling to the floor, it will be found that mosaics are quite as beautiful and useful here as in the more exalted positions. The antiquity of this mode of floor-decoration, and its common use in ancient times, cannot be doubted, for we read of it in the Book of Esther; and we know that not only Cicero had pavements of this kind placed in all the porticos of his house, but wherever the Roman eagles flew from Britain to Mount Atlas, mosaics followed as an almost indispensable adjunct of the civilisation of the conqueror. Glass tesselation prevailed all over Italy for many centuries. Tesselated marble work, usually of porphyry and serpentine, was used for church purposes for a still longer period, and some of these, as that in the Duomo of Sienna, are large and elaborate compositions in light, half-tint, and shadow.

Another floor-decoration, wherein there is wide scope for art, is that known as parquetry, in which various coloured woods are arranged in geometrical patterns, as may be seen in many of the good old houses in France. This method has been lately adopted in England, and, for many reasons, it is to be hoped that it will one day become common in this country also, where, in the warm, dusty months of summer, it would be so decided a luxury.

For the hall-floor a new branch of manufacture has also been lately started in England. I refer to the cheap and durable, and at the same time beautiful, decoration by encaustic tiles. The happy alliance of art with the resources at the command of the modern workman have enabled the Messrs. Minton to produce tiles as beautiful as those of the ancient Romans, and very little more expensive than common stone pavement.

The use of carpets, which I have purposely reserved for the last, brings me at once to the consideration of textile fabrics, in which a wide field for art display opens up to us, but one which I must run over hurriedly if I would not exhaust the patience with which you have hitherto been good enough to follow me. In touching even thus lightly, however, on the beautiful productions in this branch of manufacture, we must separate well in our minds the two classes into which it is divided by its ministration—in the one case to personal adornment, and in the other to household use. Everything, from the simplest calico print to the richest damask, if used for furniture, is governed by laws of taste entirely different from those which obtain in the whole range of fabrics intended for dress. Different, however, as are these two classes, for the true and grand traditions of art in both we must place ourselves humbly at the feet of the same teachers—the famous art-workmen of the East. In their sunny regions the sense of beauty seems never to have been wanting, whatever department of manufacture they have occupied themselves with. We have engravings, published in 1750, of vases which were then to be found in the museum of the Emperor Khian Loung, and which for beauty of form and grandeur of decoration cannot be surpassed, and yet these vases belong to an epoch 1800 or 2000 years before Christ, when the Greeks had not even yet been heard of. Who does not know the fame of the jewels of Lahore, the ivory and porcelain of China, the arms of Kurdistan, the lacquer-work of Satzouma, the bronzes and papers of Japan, and (what is more to our present purpose) the damask and velvet of Aleppo and Chiraz, the gauzes and muslins of Gwalior and Agra, the carpets of Smyrna, the satins and nankins of the celestial empire, and that unrivalled production the cashmere shawl, which comes from the valley whose "roses are brightest that earth ever gave"? And yet it is a fact that the stuffs of Babylon and Memphis, of Tyre and Alexandria, of Byzantium and Trebizond, are as beautiful to-day as those which are still manufactured according to the same traditions in Constantinople or Broussa, in Persia, India, or Pekin. These productions are not only beautiful, but they seem to be everlasting. I do not speak now so much of the tables, coffers, cabinets, etagères, vases, and other similar products of oriental manufacture, on which porcelain, mother-of-pearl, shell and graven ivory are encrusted with such marvellous skill, and whose faithful designs and irreproachable harmonies endure for ever as testimonies of the fine and unerring taste of the artist-workmen of these countries. Even those more perishable fabrics, which amongst us "outer barbarians" so soon lose their brilliancy and beauty, partake in the East of the durability which seems to belong to all Eastern work. In Persia, when summer comes, the marvellous carpets are taken up and placed for a fortnight in the bottom of a river, from which they re-appear more brilliant than ever; and it is well known that many of them are to be seen in that country, which after three or four hundred years' use are as fresh now as when they were first made. France, too, it must be admitted, has held for centuries a high position in carpet manufacture. The magnificent products of the Gobelins, the Savonnerie, and Aubusson, are works worthy of the homes of kings. The carpets of the Gobelins manufactory, in addition to their artistic value, have, like Eastern work, the priceless quality of everlasting solidity. Friction and wear only increase their durability, as they have the effect of drawing closer the knots which fasten the wool to the warp. The Savonnerie carpets are the largest made. They are generally white, with arabesque borders, in which the delicacy of the dyes, the harmony of the colours, and the skilfulness of the workmanship, defy all western competition. At Aubusson, it is well known, the principles of the art and the aptitude for execution are traditions in certain families, and no other place can produce such a staff of workmen. It is worthy of remark, however, that even there, where the apprentice is accustomed from infancy to handle his father's frame, it takes fifteen years to qualify for the work.

The teachings of art with regard to this manufacture are, perhaps, clearer than in reference to mural decorations. Whatever we may think of relief and natural ornament upon the walls and ceiling, I think we can hardly help admitting that flatness is a most wholesome feature in floors. It is uncomfortable to walk over hill and water in a landscape, to trample on living creatures, and to feel in constant danger of being tripped by some other formidable reality; and hence, however excellent these things may be when taken separately, there can be little doubt but that they are bad and false as floor decorations. Floral designs are the only imitations of natural objects that may be properly introduced, and whatever Mr. Wallis and other authorities may say of the want of knowledge of those who admire flowers in carpets, I cannot but think that they are perfectly suitable, and that their effect is artistic in a very high degree. If this be an error, I am quite satisfied in this respect, at least, to err with Mr. Ruskin, who says he "cannot see, since the first thing we usually do to make the ground fit to be walked upon by any festive procession is always to strew flowers upon it, why we should refuse to have flowers on our carpets."

Other textile articles of furniture, such as window curtains and, in a still greater degree, table linen, should be exceedingly simple in pattern, as it is obvious that the use in one case, and the folds in the other, preclude the possibility of all elaborate ornamentation, which would be distorted on the window and incongruous on the napkin.

And now I approach those manufactures in which art is employed to heighten their power of personal adornment and make them harmonise with the character of the figure which they array. In some respects it is a delicate subject, because I am afraid I can hardly touch it without "fluttering the dovecots of Corioli," displeasing the ladies as well as the fashionmongers, who are their oracles of taste. In this free country, and in free England, our ladies enjoy an almost unlimited liberty in dress as well as in other things. They are restricted neither to the mantilla of "Spain's dark-glancing daughters," nor to the veils and shawls of their Turkish sisters. They dress, in fact, according to their own sweet will, and the use they make of their liberty is to attire themselves all alike in whatever extraordinary costume the last fashion-plates from Europe may introduce. Sometimes the gowns of our wives and sisters are abbreviated petticoats, in which Venuses that may be said to be of the Doric order of architecture are seen to great disadvantage. Sometimes they are lengthened out to an inordinate degree, and a train that would be becoming only in a drawingroom is dragged through the dust of Collins-street, to the infinite inconvenience of the male frequenters of that Rialto of fashion. Sometimes, again, our ladies' dresses are straight and bare as a friar's frock, and anon they are monstrous in their amplitude, and over-abounding in paniers and puffs. As long as the hair is of the new colour, the dress of the style worn two months ago in London, the hat of the latest bandit or gipsy shape, and the ribbons and jewellery in strict accordance with the prevailing mode, they think they have done all that can be required of them by the most exacting critic.

I wish I could place before you some work of Holbein's or of Paul Veronese's—it would teach you more in five minutes of the uses of art in the manufacture of garment materials than I could tell you in hours. Nothing can be nobler than their robe embroideries. The magnificence of colour, the subtle beauty of design, the harmony of texture and ornament, and the due subordination of all to the prominence of which the figure should never be deprived, are really marvellous to behold. In a general way, however, I may tell you that art requires brocade and such costly material to have a rich treatment, while the pattern on muslin bareges and cotton should be small, and founded on a regular and severe basis. A few more general principles are that the closer the fabric the smaller must be the pattern, that in woollen goods it should closely cover the ground, and that all patterns which cross the fabric so that they run round the dress when made up should be avoided.

Closely connected with textile fabrics, in their double office of household utility and personal decoration, are the manufactures in which the materials are the precious metals and the precious stones. Artists have at all times loved to lavish their labour upon these costly substances, not indeed because of their money value, which is a matter quite unimportant from a purely artistic point of view, but rather for their durability, a quality which every true artist prizes highly on account of the immortality it promises to his work and to his thoughts. The greatest monuments of stone and brass that human genius has produced are long ago lost in the waves of time, but the indestructible gold and the ever-flashing jewel discovered to-day in an Egyptian sepulchre are as perfect as when they were first placed there. Indeed, if gems and golden ornaments had no artistic beauty, but were in the one case badly cut or inappropriately used, and in the other monstrously designed, then indeed we might say with Ruskin that such things were fit only for "the adornments of the chariot and the trappings of the steed." Art it is that gives them their highest value, and makes them fit to take their place on the brow of beauty or on the sceptre of a king. Gems might have been hollowed into cups for the banqueting-hall of Cleopatra; but if they were made the vehicles of no high thought, if no beautiful art was entrusted to their everlasting keeping, then they were fit for nothing better than to hold some costly wine to the lips of a drunken Cæsar. In this, as in every other branch of art-manufacture, the French are by general consent allowed to be pre-eminent for grace and novelty of design, for vivacity of fancy, and for scholarly and well-selected reproductions. The English, while inferior in these respects, have, however, of late years made wonderful progress, and their work, if not quite so rich in art qualities, has ever had a solidity of structure and an excellence of execution which are by no means undeserving of high praise. It is said that a certain Austrian nobleman never danced without shaking off several hundred pounds value from his diamond ornaments. This I can perfectly understand might happen if the settings were French, but would hardly ever occur, I think, if they were English. The problem which the jeweller has to solve is to unite, as far as possible, the delicacy and beauty of French work to the soundness for which that of our own countrymen is distinguished. In this, as in all other branches of art, we must go back to the concurrent testimony of past ages for the principles of taste by which they are to be guided. It is, therefore, much to be regretted that we have no specimens of ancient jewellery, or even clever reproductions of well-chosen models, to which the student could be directed for instruction or suggestion. If we cannot have a Campana museum, such as was added some time ago to the Louvre; or a priceless collection, such as may be found amongst the treasures of the Hotel Cluny; or examples of the fine historical jewellery of the Italian peasants, such as were lately purchased from Salviato of Rome for the South Kensington Museum—it might be worth the attention of the trustees of this institution to procure some electrotype reproductions or some photographs of the best work of the kind of various epochs, and even to make a beginning of collecting such originals as opportunity and their resources might place within their reach. This would soon rid us of the wretched design and inappropriate ornament with which one is so often shocked in the personal jewellery we notice as we walk through the principal thoroughfares of this city, and which are so different from what would meet the eye on the Pincian in Rome, in the Champs Elysées in Paris, or even in "the Row" in London.

A wide distinction there is between those works in the precious metals which are intended for personal adornment and those designed for use as well as beauty. "In the one case fancy may be indulged," says a popular writer on the subject, "to almost any extent, in the other the utility of the object will govern its form." This beauty of fitness, or truth of construction, rejects every ornament inconsistent with it as a senseless and unjustifiable extravagance. If art, however, be more restricted with regard to form in gold and silver objects of use than in those of mere ornament, it must not be thought that the artist does not find as congenial a field for his labour on the noble service of plate made to be a family heirloom, as on the parure destined for a royal bride. Some of the most potent wizards of the pencil or the chisel have produced designs for silver work, Perugino, Raphael, Michael Angelo, and Giulio Romano amongst the number; and one man's name (need I say it is Benevenuto Cellini's?) has become immortal by its connection with this work alone. Once the contour is fixed, the enrichments, whatever they are, should grow naturally out of it, or should help to make it, but should certainly never be allowed to disturb it in the slightest degree. In these limits, however, much rich and worthy art-work may be produced. I must say that in this direction I have seen some efforts of our Melbourne silversmiths that could not be described otherwise than as highly meritorious. Presentation plate has sometimes appeared in the windows of one or two of them, which certainly spoke well for the taste of the designers, and their sense of appropriate ornamentation. A want of originality no doubt may be noticed, for the types of the aboriginal, the goat, and the kangaroo, have become almost as fixed as those of man and animal were in the art of the Assyrians; and beyond a fortuitous meeting of these various creatures, with the addition or substitution of an emu or some other specimen of our living curiosities, I am afraid that the invention of our local workers in silver very rarely goes. Works of this kind, more than perhaps any other, should in their entirety convey a thought which every individual ornament would help more clearly to bring out. The thought should meet the eye distinctly and at once, impressed on the whole design, and on every part of it; and even the treatment —large, generous, and free—should aid in giving a sort of frankness and sincerity to its impression.

Talking of personal and house ornamentation, I can hardly avoid saying a word about lace—that delicate and most artistic fabric, which adds such an air of elegance and brightness to the household, and aids so gracefully in enhancing the charms of female beauty. Its classic home is Belgium, but France has long been a powerful rival to that country, and Honiton and Limerick are surely not unknown to fame. Its manufacture has always proved a source of national wealth in Belgium, but it is now more flourishing than in the most palmy days of the Netherlands. Lace-making forms a branch of the public education, and employs, it is said, one-fortieth of the population. This in itself is a proof of the utility of art in manufactures, for it is not only to its fineness, but to its beauty, that Belgian lace owes its world-wide renown.

Brussels lace is unrivalled for its artistic treatment, as well as for its delicacy; and the elaborate and tasteful workmanship of Valenciennes is as well known as its solidity, which gained for it the name of "*eternelles Valenciennes.*" In France the most celebrated centres of this beautiful art-manufacture are Alençon, Normandy, Auvergne, Lille, and Arras. The point d'Alençon is the most costly of all kinds of lace. It is the splendid fabric of which were composed the cuffs, and garters, and shoe-roses, and falling collars, of the magnificent court of Louis XV., and of which such matchless specimens appeared in the *corbeille de mariage* of the Empress Eugenie. The curtains and bed-trimmings of the cradle presented by the city of Paris to the infant son of Napoleon III. were of this material, and cost nearly £5000. To such value may materials of the cheapest kind be raised by the happy combination of artistic and manual skill.

The uses of art in the making of furniture is a subject which itself alone would require, not one lecture, but a course of lectures to do it justice. One of the first good effects which art-teaching would have upon this manufacture would be to banish for ever many of those forms with which we are so familiar, and in which the greatest amount of ugliness is united to the least possible amount of comfort; to make short work of all those gaudy inflations and pretentious devices which give our modern house-interiors such a shoppy and snobby appearance, and to give our furniture correctness of structural design and appropriateness of ornament, instead of the meaningless imitations, the lawless luxuriance and extravagant caprices which vulgar ostentation has of late years called into existence. "Beauty," says Sir Gardner Wilkinson, "is not to be obtained by capricious ornament such as overloads so many of our modern productions, for unless the maker knows why the particular form and all the ornamental accessories are given to his work, any splendour of decoration which may merely delight the ignorant will only be looked upon by men of good judgment with the greatest dissatisfaction." This is not to say, however, that house furniture should be deprived of all magnificence of ornament. The choicest woods (and any one who passes through our Technological Museum will see what a splendid variety we in this country have to choose from), coloured stones, bronze, ormolu, and Florentine mosaics, may all be used to give imperial opulence to the drawingrooms of the wealthy, if only they are used in accordance with the dictates of good taste. Tarsia, and other sorts of marquetry, may take their place in homes where economy is studied. But in all good art-workmanship of this kind, whatever be the materials employed, there should be cleverness of design, happy blending of colour, purpose in the placing of each detail, and intent in every touch. With these the result is sure to be satisfactory, whether you use ivory inlays to enliven the sober tones of walnut, and focus the colour in masses of agate and lapis lazuli, or search for polychromatic variety and concord in the juxtaposition of ebony, gold, porcelain, satin-wood, and silvery sycamore. Carving is, however, the most legitimate and appropriate of all means of ornamenting furniture. The display of fancy and the *finesse* of execution for which there is here so wide a field, is the decoration which a man of taste will prefer to all others. Those who would wish to see in what manner artistic carving may be made to heighten the beauty and consequently the value of household furniture, cannot do better than examine attentively the magnificent Italian chimney-piece, of which we have a copy in our Art Gallery. This noble work of art-manufacture, which formerly belonged to the Counts Petinelli, at Padua, and is supposed to be the production of one of the Lombardi family, who sojourned in that city towards the beginning of the sixteenth century, was purchased in Italy by M. Soulages, for his valuable museum, which is now the property of the English nation. Amid all its rich profusion of ornament—its baluster-shaped shafts unsparingly decorated, its projecting corbels representing marine divinities, its carved mouldings on cornice and entablature, and its figures in full relief upon the frieze—the most perfect harmony of details, and the completest unity of character, as well as the utmost skill and the highest finish, are stamped upon the entire work. Such an example as this will do more than a hundred lectures could do to spread correct notions of the relation between art and handicraft.

And now I must hurry on. The only remaining branches of art-manufacture on which I can touch this evening may be all comprised, in a loose way, under the head of furniture. They are the manufacture of glass, of bronze, of ironware, of porcelain, and pottery.

The glory of glassware might, until very lately, have been said to belong to a past age. No doubt our flint-glass, owing to the use of lead in its composition, is of a much more crystalline purity than was ever dreamed of by Venetian artists; but, unhappily, this very ingredient precludes nearly all possibility of artistic treatment. The material cools so quickly during manufacture, that no time is left for the display of skilful handiwork or delicate taste. Hence it is that, up to a very recent date, the quaint and elegant forms, the graceful and fantastic ornament, the dainty touches of colour, the mellow and jewel-like effect, which were common to the glass manufactures of Venice in the fifteenth century, were unknown amongst us, outside the curiosity shops where the rare specimens still preserved were sold at ten times their original cost. Neatness indeed we had, and brightness, mathematical precision, and sometimes even nice engraving, but the countless colours and forms of old filagree were gone, and the rich golden lustre of *avventurino* was no more. To an Italian gentleman of our own time—a scholar and a lover of art—is due the honour of having resuscitated this beautiful industry; and now the glass-workers of Murano, amongst whom the traditions of the lost art had never been entirely forgotten, produce works which will bear comparison with the best productions of former times. Bohemian glass is one which alone never forfeited its reputation, but it must be admitted that until within the last few years its decorations in gold left much to be desired. The green glass of Bohemia is now, however, not only superb in tone and quality of colour, but the contrast with the raised gold is of the most charming and artistic effect. French glass is elegant and correct in taste, like all other art manufactures of that country; and French chandeliers are remarked for a greater perfection of cutting for the purposes of illumination than is generally to be found in similar articles elsewhere. English glass has lately improved considerably in design. We no longer use the inverted cones, from which our grandfathers drank their "fine old tawny," and champagne sparkles now in a broad tazza of elegant shape, instead of being confined in the long narrow glasses which many of us may remember. Water-bottles, claret-jugs, salt-cellars, preserve-jars, flower-stands, vases, all display more refinement than the articles did some fifty years ago, and their value has proportionately risen in the markets of the world.

Glass-painting and glass-staining are branches of art-industry quite different from one another, and the latter, of course, quite distinct from the manufacture of articles in glass. In stained glass the colouring is not superficial, but pervades the substance of the glass, and is obtained by mixing metallic oxides with the glass in a state of fusion. Of these industries however, I need not speak, as art is obviously necessary wherever colour is employed, and glass-painting, in which Lorenzo Ghiberti, Claude, and Bernard Palissy distinguished themselves, though purely a monumental decoration, approaches so nearly to fine art that its highest merits must be always of an æsthetic nature. A pure and correct style of drawing without any elaboration of detail, and a simple and vigorous rendering of the subject, are the qualities which the painter in glass must before all things endeavour to attain. At a distance the colours and forms should make a harmonious whole, and only on closer inspection should the elements of the general effect be perceived. This is a secret of decoration that has not hitherto been much noticed, but it is nevertheless of the very utmost importance, as I believe that in it lies the solution of many of the difficulties about which ornamentalists are so divided. Good decoration of this kind, proving really pure and true when examined, and yet unobtrusive of form and detail when looked at as merely part of the building it adorns, should, I think, satisfy the followers of nature as well as the orthodox disciples of the conventional school.

The art-industry of decorative bronzes is another of those branches of my subject of which I need say but little. The successful manner in which art has been applied to it in France is a source of immense wealth to that country. And "this success," says a writer on the subject, "is based on the special preparation and education of the workers. . . . Thus, competitors with France must commence, not with the foundry and the workshop, but with the school of art, and gradually train the student in designing and modelling for metal-work, or educate the young worker in the class-room. In no other way can the skill which exists in the extensive *ateliers* of the bronze manufacturers of Paris be emulated, still less rivalled." The fact that our climate is highly favourable to the display of this material should be an inducement to Australian artists to turn their attention to bronze decoration. Its exquisite and varied tones are imperceptible in a scanty, diffused light, but are brought out in all their sombre and harmonious beauty under the brilliancy and the consequently sharply-defined shadows of an atmosphere so pure and sunny as this of ours.

From bronze to iron is not an abrupt transition. There is scarcely any material which affords wider scope for art than iron, by reason of the ductile and tenacious qualities which it possesses in so eminent a degree. Hence it is that no branch of trade shows more variety of design than that of the ironmonger. Those who have travelled in Italy will know with what consummate art it has been beaten and dragged into delicate lines, and fair forms, and fantastic imagery, by the old workers of the quattrocento and succeeding century. The town of Siena, the streets of Florence, the garden walls of Brescia, the balconies of Bellinzona, are rich with the freedom and fineness of this ancient art, here rising in sprays of foliage, there twined in capricious tendrils; here falling in tassels, there clustering in wreathed flowers. Two of the little Alpine towns have, to use the words of Ruskin, "complete schools of ironwork in their balconies and vineyard gates." Copies of this work should be constantly before the eyes of those who would learn the use of art in this branch of manufacture, and I know of no fairer examples than the gates of Ghiberti, of which I have had a few of the panels brought here from the School of Design for your inspection. Angelo said they were fit to be the gates of Paradise, and after that they require no further praise. Another very extraördinary specimen of ironwork is that shield in *repoussé*, representing the Apotheosis of Rome, with which visitors to the National Gallery must be familiar, and which is the work of George Sigman, one of the famous old goldsmiths of the imperial city of Augsburg. The influence of such examples would soon rid us of the lacquered ugliness of Birmingham patterns of stoves and fenders, candelabra and coffee urns, which are remarkable for nothing so much as for their meretricious extravagance of style, and we might once more expect to see even fire-dogs made beautiful with art, as they were in the time of Shakespeare—

> "——the roof o' the chamber
> With golden cherubims is fretted; her andirons
> (I had forgot them) were two winking cupids,
> Of silver each, on one foot standing nicely,
> Depending on their brands."

And now we reach the last branch of manufacture of which I propose to speak, that most ancient and most artistic one which is described under the generic name of ceramic ware. Made of the most worthless of all materials, some of the triumphs of this industry have become, by the power of art, things of inestimable value. Looking through the Sèvres manufactory, as I have often done, and admiring the soft and brilliant colouring, the glowing landscapes, the gay figure subjects, the pictures of the Boucher and Watteau class, the shepherds and shepherdesses in satin, the noblesse of past centuries, the powdered gentilhommes and high-heeled dames of the court of Louis Quatorze, and the rest of the brilliant pictorial display which there meets the eye, one may well fancy himself in a gallery of paintings, and be disposed to claim for ceramic decoration the dignity of fine art in its highest and most exclusive sense. Pictures I have seen there of which Meissonier might have been proud; flowers worthy of the old Dutch painters; colours such as the *bleu de roi* and the *rose Dubarry*, unrivalled for their delicacy of tint; and works which, both for their constructive and ornamental art, were precious beyond their weight in jewels or in gold. Those who are acquainted with the manufactories of Dresden and Berlin also know something of what art can do for porcelain; and whoever has visited the Marquis Ginori's establishment in Florence will treasure the sights he has seen there among the most beautiful reminiscences of his Italian travels. It is well, however, to remark that the Dresden ware, of which we have some examples in the Technological Museum, is by no means the perfection of fictile art. The first European manufactory of porcelain was established at Meissen, near Dresden, but the art of the Saxon capital even in that period, which courtiers used to call its Augustan age, was ever false and extravagant in character. Rococo is the style to which it owes its architectural physiognomy, the statues in its public places are too often those of the German disciples of Bernini, and the paintings with which Heinecken once inundated the state collection are certainly not adapted to elevate the public taste. It is not therefore astonishing if, under such influences, the Government porcelain works produce nothing better than delicate toys in which real æsthetic merit is rarely present. The reproductions on porcelain of four celebrated pictures, which may be seen in the Technological Museum, and which are also of Saxon manufacture, are, however, works of very considerable interest. Considering the many difficulties which attend the process, it must be admitted that they are highly successful. Each of these productions is painted at least three times over, and the colours burned in after each painting, so that not only the very nicest accuracy is needed in allowing for the action of fire upon the pigments, but the most anxious care lest accidents should occur. Notwithstanding all the skill and attention of those who are long accustomed to the work, the colours often turn out unsatisfactory, and frequently twenty plates are destroyed before one comes forth unscathed from the ordeal. These difficulties will of themselves prevent this mode of reproduction from ever becoming popular, but successful specimens (such as we now see before us) are worthy of attention as examples of the higher capabilities of ceramic art. British factories have produced pottery and porcelain decidedly superior to this Dresden ware, and ever since the days of Wedgwood this industry has been stamped with a beauty and excellence which even in France and Italy is rarely surpassed. No European establishment has yet discovered the secret of the great era of Chinese porcelain, notwithstanding all the chemical knowledge and the artistic resources of our time; but it is satisfactory to us to know that English artisans have produced works which so closely imitate the *dolce color d'oriental zaffiro*, and all the other characteristics which are associated with the dynasties most renowned in celestial ceramics, that even judges are sometimes deceived. As a proof of this, I may relate an anecdote which I have from excellent authority. Not long ago the warehouse of Mr. Hewett, of King William-street, was visited by some gentlemen learned in pottery, one of whom was celebrated as a liberal and enthusiastic collector. They examined some china of a watery-blue pattern. Suddenly one of the authorities, as if struck with some idea of peculiar importance, drew forth a magnifying-glass and applied it almost tremblingly to the lower part of the plate. A moment was enough. "Ha!" said he, "I thought so—Ming dynasty." The proprietor wisely was silent in the presence of his customers, but as soon as they were gone his first words to a friend who witnessed the scene were—"Ming dynasty! It was made by workmen last year."

I cannot tax your patience any further. There are, of course, many other branches of manufacture of which I might speak, but those which I have mentioned will suffice to give you some notion of the wide and splendid field for human industry and the immense sources of wealth that are opened up by an intelligent union of art and design with the labour of the hand. The value of art-power in the workman is now, however, daily growing throughout the world to be not only appreciated, but absolutely required. Even in England, which was so long a time behind some of the other countries of Europe in this respect, ugly, inartistic designs will not sell at present, and the articles of French manufacture which command the market do so for no other reason than because of their superior beauty. No money or pains are spared to raise the English workman in the scale of artificers, and to place him on a level with his fellow-toilers in other lands. Last year, in addition to the large sums voted to galleries and other institutions connected with art, £34,000 was spent in schools in which art instruction is given to the working classes, and these schools were attended by 18,690 students in the day, and 7258 at night. Exhibitions are made to aid also in the good work. Besides the South Kensington Museum, which is permanent, not a year passes without displays of art-manufacture for the education of workmen; and last May was opened the first of a series of International Exhibitions in London, which are henceforth to be held annually, and in which an immense field of study is opened to the designer for industrial purposes. In this great movement which is now spreading over the whole earth, it is absolutely necessary that we should take our place. If we do not, the time will come when Victoria, which should be the great manufacturing centre of these southern lands, will have to import perhaps from some neighbouring colony many of the articles used by her own people. Far from us such a disgrace! Shall we not hope rather that the day may come when, in this land of wealth and liberty, as in the free republics of Venice, Pisa, and Florence, and amongst the commercial communities of the Rhine, art may flourish in all the grandeur of creative power, and our workmen may rival the Tafis, the Ghibertis, and the Palissys of old? But, if we wish for such a future, the attention of the working classes must be aroused to the importance of art-instruction. If these words bear the fruit that they should, art-education for the people will henceforth be dealt with in a more thoughtful and liberal manner than in the past, and our manufactures will be amply and worthily represented at the exhibitions held in London every year. Instruction—Rivalry; these are the two souls with which our workmen are to be animated, and the task of doing so is worthy of the noblest minds amongst us. On it depends, in no small degree, the future greatness and prosperity of the new empire which it has fallen to us to found, for we must ever remember that, on these southern shores, which were first pressed by the foot of civilised man within the memory of most of us—

"We are ancients of the earth
And in the morning of the times."

PAINTING AND PAINTERS.

A LECTURE,

DELIVERED BY THE HON. THOMAS TURNER A'BECKETT, M.L.C.,

On 12th OCTOBER, 1871.

It will easily be understood that all the details of so large a subject as that of painting and painters cannot be brought within the limits of a single lecture. I shall not attempt more than the sketching a series of outlines, which those who are disposed to do so may fill up at their leisure, with more or less finish, from the abundant materials for such a work which may be found within the walls of the institution of which this lecture-room forms a part.

Painting does not rise to the dignity of art until employed in the production of what we all call a picture. In this form it is accepted as the symbol of art itself. All who practise an art are entitled to be ranked as artists, but we do not give this designation in its general sense to any but painters; the followers of other arts must have the art particularised with which they are specially associated in order to fix their position in the artist world. Millions derive enjoyment in a higher or lower degree from the results of pictorial skill, who would be insensible to the charms of art exhibited under any other form; and we cannot but recognise the fact that painting has contributed to the mental gratification of the human race, through the medium of the senses, in a much larger degree than any other art which has been practised by mankind.

Before entering upon the main subject of my lecture, I will occupy a few moments in giving a short description of the principal kinds of painting with which we are acquainted, or of which we have any record. The earliest method of painting known to have been practised was in use long before the Christian era, and is still resorted to as being, under certain special conditions, the most effective that can be employed. It is called "fresco," the term fresco—a word which signifies "fresh"—having been applied to it in Italy, where the art of painting in fresco has long been, and still is, very extensively exercised. It is a kind of painting that can only be successfully executed by very skilful artists, as the work must be carried on with great rapidity, and will not admit of correction while in progress. The groundwork of the picture is plaster, prepared with the utmost care, and with the greatest attention to the selection of the ingredients employed in its composition, and this plaster is kept in a moist or damp condition until the picture is painted into it with water-colours. The effect, under skilful treatment, is satisfactory in the highest degree. The colours, when the material is well prepared and the picture is properly protected, preserve their first freshness and brilliancy for an almost indefinite period; and the surface being perfectly free from gloss, the painting can be seen advantageously from any point of view. Fresco painting is applied principally to mural embellishment. It is only recently that its value for such a purpose has been fully understood in England, where fresco painting fifty years ago was scarcely ever practised. The finest English specimens of fresco painting are in the Parliament Houses, and the largest in the new hall of Lincoln's Inn, the picture covering an area of 1700 square feet. Splendid specimens of fresco painting may be seen in all parts of Italy, the most exquisite being those at the Vatican, the productions of Raffaelle and Michael Angelo.

The most durable pictures are produced by a process which can only be applied to works of art intended to remain permanently in the place first assigned to them; it is called "mosaic." The picture is formed of very small pieces of coloured glass or stones, so fitted together as to present the appearance of an ordinary painting. Mosaic painting is of the very highest antiquity. Pliny describes, with some minuteness, a picture in mosaic which appears to have had great attractions, and some exquisite specimens of mosaic pictures have been discovered in the remains of Pompeii. This curious art is largely practised at Venice, where it has been in use for many centuries. The pictures that ornament the front of St. Mark's are executed in mosaic, as are almost the whole of those in the interior. The altar-pieces in the various side chapels in St. Peter's, at Rome, are copies in mosaic of celebrated pictures, and are so exquisitely wrought that it would be quite impossible at the distance from which they are seen to perceive that they are not hand-paintings. It is said that every one of these mosaic pictures cost six thousand pounds.

The mode of painting generally practised by the ancients in the production of easel or movable pictures was called "encaustic," from a Greek word signifying "burning in." The colours used were mixed with wax, and when applied to the pictures, were blended into each other by heat. It was practised from the time of Alexander the Great, until about the fourteenth century, when it was superseded by oil painting as now practised. Oil painting was introduced in the year 1410, by one John Van Eyck, a Belgian, and appears to have created an immense sensation among the followers of art, equal, as it is said by some writer, to the discovery of gunpowder about a century earlier. Painting in "distemper" is painting with colour mixed with size or white of an egg instead of oil, and is employed in painting pictures which are to occupy very large surfaces, and which it is necessary for the production of their desired effect should be free from gloss. It can be laid on canvas or other material with very great rapidity, and is always used in scene painting. Painting in water-colours I need not describe.

The preparation of colours has now become a separate calling, and has immensely facilitated the work of the artist, who, not many years ago, had to devote an enormous amount of time to this kind of labour, which was entirely unconnected with artistic skill, but without which no artistic skill, however great, could be made available. You will be able to judge of the extent of this drudgery by the following extract from Cennini's treatise on painting, written in the fourteenth century. In treating upon the manner in which the art of painting pictures should be acquired, he writes thus:—"Know that you cannot learn to paint in less time than that which I shall name to you. In the first place you must study drawing for at least one year; then you must remain with a master at the workshop for the space of six years at least, that you may learn all the parts and members of the art, to grind colours, to boil down glues, to grind plaster, to acquire the practice of laying grounds in pictures, to work in relief, and to smooth the surface, and to gild; afterwards to practise colouring, to adorn with mordants, paint cloth of gold and paint on walls for six more years, drawing without intermission on holy-days and work-days, and by this means you will acquire great experience. If you do otherwise, you will never attain perfection."

In no period of the world's history has pictorial art been more cultivated, more generally practised, or better patronised and rewarded, than at the present day, and it is difficult to imagine that there ever could have been a period of time in past ages, during which the art of painting was unknown, or its efforts unappreciated. It is, however, impossible to ascertain the degree of estimation in which painting was held in the earliest times, and difficult to judge of the degree of perfection to which it had attained at a very distant era.

It is remarkable that there is not a single passage in the Bible to justify the belief that painting, as an imitative art, was followed or esteemed by the Jews. They certainly had a great appreciation of the beauty of colours, and used them freely for the purpose of ornamentation, in their costumes and in their dwellings. Tapestry work seems to have attained to great perfection, and to have been highly valued, if we may hold, in testimony thereof, the song of Deborah, wherein she describes the mother of Sisera as watching impatiently for his return from battle, and saying within herself, "Have they not divided the prey—to Sisera a prey of divers colours, a prey of divers colours of needlework on both sides, meet for the necks of them that take the spoil." There are several passages in the prophetical books showing that painting, with the view to the production of a pleasing effect, was commonly practised, but of notice of any painting, corresponding to pictures such as those that are now regarded as works of art, there is not a trace. The Jewish people may have considered such a picture a "creation" which would have been an infringement of the letter of the second commandment, and this may have prevented their practising painting as an amusement, or countenancing it as an occupation, although they disobeyed the spirit, as well as the letter of the commandment, in its grosser form of image worship. I am the more inclined to the opinion that they considered imitative painting a breach of the divine injunction, from the fact that in the early ages of Christianity the converted Jews looked upon painting in this light, and destroyed, therefore, many splendid works of art. A letter is preserved, written in the fourth century by the Bishop of Salamis to the Bishop of Jerusalem, in which this passage occurs:—"On my journey through Anablata, a village in Palestine, I found a curtain at the door of the church, on which was painted a figure of Christ or some saint—I forget which. As I saw that it was the image of a man, which is against the command of Scripture, I tore it down and gave it to the church authorities, with the advice to use it as a winding-sheet for the next poor person who might have occasion for one, and bury it."

Although, however, there seems reason to believe that painting was not practised by the Jews, there is no doubt whatever that more than 2000 years ago it had attained a degree of excellence, certainly not much below, and probably equal to, that which exists at the present day. This is proved by the evidence of the historian, by the remains of paintings that have been discovered, and by other works of art which have been preserved to the present time, and which show a correctness of form and a beauty of design and expression which constitute them even now models of grace and beauty, which it is the highest aspiration of the artists of the present day to follow, and if possible surpass.

The highest and best authority we have on the subject of ancient art is Pliny the elder. He was born in the year of our Lord 23, in the reign of Tiberius. Among other works he wrote one on Natural History, in thirty-seven books, which are now extant. In the thirty-fifth of these he wrote largely upon Painting, and he gives an account of art and artists from the earliest period of man's history up to his own time. It is from this book the greater part of the information extant on the subject of ancient art has been obtained. Pliny tells us that in his day the Egyptians asserted that they had been masters of painting for 6000 years, and describes this as "evidently a vain boast." When the Exodus took place, about 1500 years before Christ, the Egyptians were, no doubt, the most civilised people in the world, and Moses, it is said, was "learned in all the wisdom of the Egyptians;" but we find no allusion whatever in the sacred record to the skill of the Egyptians as painters. That they understood colouring there can be no doubt; but although the remains of their paintings, of which we have many in almost every museum, show great brilliancy of colour, they are grossly deficient in imitative power. It was more a kind of picture-writing than painting that the Egyptians practised, as we can perceive by their mummy cases; they had some knowledge of proportion, as is shown by the gigantic figures which are still extant, and which, notwithstanding the vastness of their size, appear to have been executed under a thorough perception of the proportion that the different parts should bear to each other. It is said that the Egyptians did not judge of the proportion of a statue by the eye alone, but that they made a small model which was divided into a number of parts, from which, in the same number of parts in any given proportion, worked by different hands, they executed their colossal statues.

Three classes of paintings have been discovered in Egypt—some on walls, some on mummy-cloths, and some on papyrus rolls. The search for Egyptian antiquities has been a favourite one with explorers. Numerous works, profusely illustrated, have been published as the result. Those which are considered the best are a French work, published by the "Institut du Caire," and one by Rossellini, called *Monumenti dell' Egitto e della Nubia.* In many of the Egyptian tombs and temples, of which the ruins still exist, may be seen wall-paintings, the colours of which appear quite fresh, and form excellent illustrations of the manners and customs of the people. Several of these have been transported to the British Museum, together with mummy cases, and many other relics indicative of the very barbarous state of painting as an imitative art among the Egyptians. There are also in the British Museum, and in several other museums, the brushes, together with the colour boxes and palettes and other implements, used by the Egyptian painters. It is supposed that many of the Nineveh sculptures in the British Museum were the work of Egyptians, introduced by Cambyses into Persia, who formed there an Egyptian colony.

It was in Greece that painting in its highest form appears to have arisen and flourished. It is supposed that the art was there introduced by communication with Egypt, where painting was known long before there is any evidence of the existence of the Greeks as a people. It was not until about 600 years before Christ that a period can be distinctly fixed at which art in Greece began to flourish, and the period of about five centuries before the Christian era may be said to constitute the first age of art. The earliest painter whose name has been recorded is one Bularchus, who painted a picture of a battle about 716 years before Christ, which was so highly appreciated by Candaules, King of Lydia, that he paid for it as much gold coin as was required to cover it. It is evident that 600 years before Christ paintings were numerous, as Herodotus mentions that when Harpagus besieged the town of Phocea, 544 years before Christ, the inhabitants, having collected all their valuables, except paintings and other works which could not easily be removed, fled with them to the island of Chios. It is clear by this that these paintings were very large, probably fresco paintings, forming mural decorations, which could not be carried away.

The first painter whose name has been handed down to posterity as a master of his art is Polygnotus, who flourished about 450 years before Christ, and is spoken of in very high terms by Aristotle. Several of his pictures are specially alluded to by contemporary writers, and show that he had vivid imagination and great power of expression. It was said of him, that as Homer was the founder of epic poetry, so was Polygnotus the founder of historic painting. I pass over the names of many artists who appear to have followed in the steps of Polygnotus, to dwell a little on the well-known name of Zeuxis, who appears to have advanced into the regions of art greatly beyond the limits reached by Polygnotus. Lucian gives a most interesting description of a splendid picture he had himself seen from the pencil of Zeuxis, which I cannot venture to transcribe, knowing how much I have to compress within the limits of this lecture. Like some of the pictures by the popular artists of the present day, one of the pictures of Zeuxis was publicly exhibited, and brought the artist a large sum of money, people flocking to see it from distant parts. Zeuxis was succeeded by a line of artists of very high reputation, whose works are dwelt upon at considerable length by writers who had seen their productions, and from the description given of them, many of these must have been wonderful conceptions, worked out with great ability. Some of them appear to have been sold for enormous prices. A sum equal to £4000 of our money is stated to have been given to a painter named Aristides for a battle-piece, which was afterwards resold for a sum equal to £6000. We could imagine ourselves reading an account of the pictures of our own time, when perusing the description given of the pictures of very ancient days; and the incidents connected with the picture-dealing that evidently went on in the time of Pliny bear a great resemblance to those of the present period. We are told of a picture of this Aristides, which had been taken to Rome, being utterly destroyed by a picture-restorer; a fate that has befallen many of the finest works of the more modern artists, under the hands of the so-called picture-restorers of our own time.

You have all heard of Apelles. His name is accepted as the representative of art of the very highest character. His world-wide reputation is due very much to Pliny, who appears to have placed him above all other painters, though his claim to the pre-eminence is not acknowledged by contemporaneous writers. He flourished in the time of Alexander the Great, by whom he was largely patronised, a circumstance which may have contributed somewhat to the impressing his name so deeply as it now appears in the records of fame. He painted the Emperor's portrait several times, and for a large picture, in which the Emperor was very prominently introduced, he was paid twenty talents of gold, equal to more than £50,000 of our money. At the time of Apelles there was an artist at Rhodes of the name of Protogenes, who had attained a very high reputation. Apelles went to Rhodes to visit his renowned rival, and examine his work. When he arrived at Rhodes he went to Protogenes' studio, but found no one there but an old woman. The good dame inquired of Apelles the visitor's name, in order that she might give it to her master on his return, upon which Apelles took a pencil, and drew, upon a large panel which he found upon an easel prepared for painting, a very delicate and beautifully-formed line; this he left on the easel as "his card," and went his way. On Protogenes' return he was told what had happened, and looking on the panel, he exclaimed, "Ah! Apelles has been here; no other hand could do that!" He then, it is said, took a pencil and drew *upon* the line of Apelles, and *within* it, a still more beautiful line, and leaving his home, told the old woman to show what he had done to Apelles when he called again. Apelles called accordingly, was shown the line within his own, and thereupon drew a third line within that of Protogenes, and said, with an air of quiet exultation, to the old woman, "Show your master that." It is said that Protogenes, upon this, gave up the contest, and owned himself beaten.

Pliny states that this panel was handed down as a wonder to posterity, and was preserved in a gallery, where it was more valued than many of the most finished paintings by which it was surrounded. It was destroyed by fire before the time of Pliny, and great doubt has been thrown upon the interpretation to be given to the term *linea*, or line, as applied to this contest of skill. Some think that the lines were really sketches or outlines of what might be regarded by the artist who designed it as the most graceful that could be imagined. Hogarth considered that he had made a discovery of a curve traceable in every beautiful form. This curve he called the true line of beauty, and took great pains to establish his supposed discovery, and Apelles and Protogenes may have had their ideal lines, which they indicated in the trial of skill I have described. What these lines really were has been very much discussed, and as I don't think I shall throw much additional light upon the discussion, I will go on to another line of my lecture.

Apelles is stated to have tenaciously adhered to a determination never to pass a day without tracing some outline, a practice which gave rise, as Pliny informs us, to the proverb still in use among us, "*Nulla dies sine lineâ.*" Pliny also ascribes to him the origin of another proverb with which we are equally familiar, "*Ne sutor ultra crepidam*"—or, as freely translated, "let the cobbler stick to his last." The incident which gave rise to it I shall shortly narrate. It was the practice with the Greek painters, as indeed it would appear to have been the practice with eminent painters in Pliny's day, to expose their pictures to public criticism, they themselves being concealed behind their work. Under these circumstances, it is said, Apelles was censured by a shoemaker for having represented a sandal with a string short, a fault Apelles corrected; the cobbler the next day observing this, and being very proud of his discernment, began to criticise the leg, upon which Apelles rushed out upon him and uttered the words which gave rise to the proverb I have quoted.

A much more emphatic correction of a painter's little mistake was made about 1800 years after this by Mahomet II., with reference to the work of one Bellini, who was sent for from Venice to paint the portrait of that sultan. As a specimen of his talents, the painter presented Mahomet with a picture of the head of John the Baptist in a charger. The sultan, who was a man of large experience in such matters, saw at once that the appearance of the severed head was not true to the life, or rather to the death; and to show the artist the real thing, sent for a slave and had him decapitated then and there—a piece of criticism, the sharpness of which so frightened Bellini that he availed himself of the very earliest opportunity he could find to quit Constantinople, to which he took very good care never to return.

Apelles was the contemporary of many artists who stand high in the roll of fame, and he and they were followed for some time by others who obtained a high reputation, but art in Greece may be said from the time of Apelles to have begun to decline. After the death of Alexander great political convulsions took place, which had a most disastrous effect upon the fortunes of Greece, and the intelligent and wealthy classes had their attention drawn to more absorbing matters than the promotion of art. The public buildings were then full to overflowing with works of art, which were transferred to other countries. Rome, when it subjugated Greece, stopped there the progress of art, and plundered it of many of its most splendid works, while pictures in large numbers were transported thither for the purpose of sale. The Grecian artists also went to Rome in considerable numbers, and found there employment and profit. Rome, in fact, became the emporium of art. The taste for art that was created by the acquisition of the art treasures of Greece, and the presence of Grecian artists, does not seem to have called out much Italian talent, for there is no record of the existence of any great Roman painter when art was the most liberally patronised at Rome. Suetonius speaks of large sums expended by the emperors in pictures by the old masters, but the artists of the day seem to have been but little prized.

Pliny tells us that in his day the art of painting had greatly declined. He speaks of it as an art which had been formerly illustrious, held in high esteem both by kings and peoples, and ennobling those whom it deigned to transmit to posterity; but as an art that was banished "in favour of marble, and even gold," describing the marble as carved out "so as to represent objects and animals of various kinds"—this being evidently the mosaic work I have before referred to. After giving a very elaborate description of the component parts of a great number of colours, he says that, with all these advantages as to colour, there was then no such thing as a picture of high quality produced. Everything, he says, was superior when the resources of art were fewer, observing that the materials, and not the efforts of genius, were in his time the object of research.

You may be curious to know whether any of these wonderful pictures that have been so eulogised in times past, and so minutely described, are still extant. There is not one remaining. Byzantium, on which was founded by Constantine the present Constantinople, became, after it received that name, more rich in works of art than Rome itself. Immense art treasures were concentrated there, and became the subjects of plunder and destruction. Immense collections appear to have been destroyed by fire. Rome also was mercilessly plundered in 410 by Alaric, and afterwards by Genseric, King of the Vandals, who ruthlessly destroyed the most splendid productions of genius, creating so strong a feeling of indignation, and leaving so deep an impression on mankind, that to this day any gross outrage upon taste, or insensibility to artistic or poetic feeling, is called a vandalism. A large list is given of terrible destructions of collections by fire, but the productions of ancient art suffered, it may be said, complete annihilation during that period of time known as the dark ages, when there arose a fanatical class called Iconoclasts, or image-breakers, who, under the influence of a blinded religious zeal, destroyed all the images and pictures they could discover—an example that was followed, in a limited degree, by the Puritans, in the time of the Commonwealth.

Notwithstanding this complete destruction of the Greek paintings of a movable character, we have a vast number of specimens of ancient painting of another description, by which we can judge pretty accurately of the artistic power of the ancients, and satisfy ourselves that it was of a very high order. Herculaneum and Pompeii were two cities buried by the eruption of Mount Vesuvius in the year 79, and all traces of them were lost until the year 1711, when their remains were brought to light. Pompeii was, as you probably all know, buried by showers of ashes; over them had formed a surface which was cultivated, and a labourer, in ploughing, turned up a bronze figure of great beauty. This excited much attention, and it was found that the whole soil for miles around was formed of the ashes covering the buried city. The labour of clearing it away proved to be very small, and the city is being gradually brought again to light. About one-third of it has already been exhumed, the greatest care being taken to preserve the relics that are found, which are deposited at the Museum at Naples. I visited the place in the year 1865, when I was informed about two-thirds of the city had still to be explored. A day or two before my visit, a fountain, beautifully decorated with mosaic work, had been discovered; and also the skeleton of a person who had probably been suffocated while asleep, as there was a great indication of repose in the position of the limbs, which the explorers had not in the least disturbed. Herculaneum was destroyed by lava, and can only be explored by excavations, it being much below the buildings erected upon its site. The art treasures obtained from the exploration of these two ancient cities threw great light upon the state of art at the time of their destruction. A large number of beautiful statues in bronze and marble, painted vases, and mural embellishments, have been discovered; besides a large picture in mosaic, representing a battle, which was discovered in the remains of a dwelling in the year 1831—a picture which shows great power of composition and perfect knowledge of perspective and foreshortening. The vases and wall-paintings would bear about the same sort of testimony to the state of painting at that time as our painted porcelain productions and the decorations of our highest-classed houses in England would bear to the pictorial skill of our present day. Pliny, in writing of the house decorations at Pompeii, speaks of them contemptuously, but Sir Joshua Reynolds formed from them a very high opinion of the painting of that day. Most of the paintings are executed in distemper, and many of the walls are coloured in fresco. Engravings have been made of all the pictures worthy of note discovered in the remains of these cities, and some of them show a grace of outline and a beauty of composition unsurpassed by any figure-drawing to be met with in the present age. The principal works (and they are very numerous) written on Herculaneum and Pompeii, and most of which are profusely illustrated, may be seen at the Public Library. The most beautiful series of ancient decorative paintings known is one illustrative of the story of Adonis, discovered in the year 1668 in some ruins near the Coliseum, and these were engraved and published in Rome in the year 1704; they are said to be worthy of any age of art, though very simple in composition.

For some centuries after the commencement of the Christian era, the practice of painting was denounced by the Christians, most of whom were then Jewish converts, who held extreme opinions as to the sin of creating objects which might become the subject of adoration or idolatry. It is stated by Origen that the Jews would not allow an artist to enter the Jewish community. In course of time the Gentile Christians exceeded the number of the Jewish, and so great was the dread of their introducing pictures into the churches, that an artist was not allowed to be baptised until he had foresworn his art, and he was excommunicated if he returned to it. The decoration of churches, however, was never totally suppressed, some of the popes and bishops encouraging the practice. In the eighth century the representations of our Saviour in the churches, which had become objects of worship, were declared by a general council of the church to be spurious.

I will pause a little in the rapid sketch I am giving of the history of painting, to consider a question of great interest—viz.: whether there ever was in existence a genuine portrait of our Saviour. The earliest known portrait is a picture discovered in the seventeenth century, which was found in some catacombs under the Church of St. Sebastian in the Via Appia, and which must have been painted about the year 220.

The portrait answers very well to the following description of our Saviour, given in a letter said to have been written by one Lentulus from personal observation, and which letter appears in the writings of Anselm, Archbishop of Canterbury, in the eleventh century. The description runs thus:—"A man of stately figure, dignified in appearance, with a countenance inspiring veneration, and which those who look upon it may love as well as fear. His hair, rather dark and glossy, falls down in curls below His shoulders, and is parted in the middle after the manner of the Nazarenes; the forehead is smooth and remarkably serene; the face without line or spot and agreeably ruddy; the nose and mouth are faultless; the beard is thick and reddish, of the colour of the hair, not long but divided; the eyes bright and of a varied colour."

There is in the Church of San Silvestro in Rome a cloth called the Sancta Veronica, on which it is said there is an image of our Saviour miraculously imprinted by Himself. The legend states that one Agbarus, King of Edessa, suffering from sickness, sent a messenger to our Saviour to come and heal him; the messenger being one Ananias, a painter, who was ordered, if he would not induce Christ to come to him, to bring His portrait. Ananias, it is said, delivered the king's letter, retired from the crowd, and then attempted to draw the sacred portrait. This, however, he found it impossible to do on account of the refulgence of the countenance; whereupon our Saviour, having washed his face, wiped it with a cloth which he gave to Ananias, with an answer to Agbarus, who found the portrait upon the cloth, and was healed by the touch of it. It is said this cloth was an object of universal adoration at Edessa, until it was removed to Rome. There are other very old legends having reference to these sacred portraits, which are curious, but which I must not dwell upon.

The period between the fourth and fifth and the thirteenth centuries is described as "the dark ages." During all this time we have no record of the progress of art, if, indeed, it progressed at all. The only trace we have of the continuance of the practice of art is in illuminated manuscripts or missals, and a series of portraits of the popes in the old Basilica of St. Paul, commencing in the fifth century and carried down for a long period, including the portraits of no less than 253 popes. These interesting pictures were nearly all destroyed by fire in the year 1823. With reference to the illuminations, they abound throughout the whole of Europe. They were the work of the monks, and show great delicacy of execution and knowledge of colour, varying much in the degree of skil displayed. Many of these are preserved in the British Museum. They improve in character as they draw nearer to our own times, and some of the fourteenth, fifteenth, and sixteenth centuries show an advanced period in art. We have copies of one or two specimens of the work of this period in our Gallery. One of the fifteenth century was purchased by Sir John Tobin, of Liverpool, at a sale in the year 1833, for the sum of £1100. The Anglo-Saxons were considered the best illuminators. These illuminations of books ceased in England at the time of the Reformation.

I now come to the thirteenth century, known as the Renaissance, or revival period, when the arts revived all over Europe, in a sudden and surprising manner. In the year 1240 a great painter was born, of the name of Cimabue, who is mentioned in the work by Vasari (which is considered the great text-book for the history of Italian art) as the painter who commenced the revival, although several artists of high character had preceded him by some years. One of the oldest paintings extant, entitled to a place in a national collection, is to be found in the National Gallery in London. It is a picture by Magaritone, and is a comparatively recent acquisition by our country; this painter died in the year 1313. Cimabue had a pupil of the name of Giotto, who as much surpassed his master as his master had surpassed others. Unfortunately, most of his paintings were destroyed by a fire which took place in Florence in the year 1771, but there are some of his frescoes in a church at Assassi, which have been engraved, and also at Padua, in a chapel which was ornamented entirely by his hand, and is called Giotto's chapel. I visited this chapel, and must confess that the paintings did not answer my expectations, attributable, no doubt, to my want of discernment of the subtleties of art. They were, most of them, injured by damp; but an excellent idea of the appearance the chapel presented when the decorations were fresh can be obtained from a coloured drawing of it in our Gallery, where it will be found in the small room at the west end of the long corridor, where also may be seen coloured copies of the work of several artists of eminence, who flourished at or about his (Giotto's) period. He painted some portraits in fresco in the chapel of the Palazza del Podesta, among which was a portrait of Dante. Some years after their execution, the political enemies of Dante covered them with whitewash and plaster; but their existence being known, many attempts were made, but without success, to discover these pictures. In the year 1840 they were brought to light by Mons. Audrey Bassi, who succeeded in removing the covering, and found the pictures in comparatively good preservation. A copy of the portrait of Dante will be found in the small room to which I have already called attention.

Art continued to progress after the death of Giotto by vast and rapid strides until it reached its golden days, constituting the era of Leonardo da Vinci, Michael Angelo, and Raffaelle, all of whom flourished in the fifteenth and sixteenth centuries. The biography of any one of these celebrated men would yield materials for two or three interesting lectures, but I am compelled on the present occasion to limit myself to a few words in referring to them. Leonardo da Vinci was a Florentine born in the year 1452, and seems to have been what is called a universal genius. There is a most interesting letter of his preserved in the Ambrosia Library, at Milan, addressed to the Duke of Milan when Leonardo was about thirty years old, in which he offers his services to the Duke, and gives a statement of what he considers he can accomplish. In that letter, which I wish I had time to read to you at length, Leonardo, who seems to have had a very versatile turn of mind, professes his ability "to make portable bridges, for facilitating running *after* or running *away* from an enemy—to burn and destroy the bridges of an opposing army—to draw away water from a beleaguered city—to destroy any fortress not built of stone—to work his way underground anywhere—to make cannon of beautiful form and quite out of the common method—to make vessels bomb-proof;" and after enumerating other feats, which he states very confidently he can accomplish, in carrying on warfare, he states:—"In time of peace, I think I can as well as any other make designs for buildings. I will also undertake any work in sculpture, in marble, in bronze, or in terra-cotta." Adding, as though that were something that it might be worth while to mention, although not of much importance—"Likewise, in painting I can do what can be done as well as any other, be he whom he may." It appears that the Duke took Leonardo into his service, and that Leonardo thought more of schemes connected with engineering than of painting, and to have had a particular fancy for constructing water supplies, which he was exceedingly disgusted at not being able to get carried out. In this respect a remarkable painter of our own day, Martin, resembled him, for Martin, when he was exhibiting his picture of "Belshazzar's

Feast," was boring the public with a scheme to supply London with pure water, effectively illustrating his invention with drawings which strangely contrasted with the work he was exhibiting. Leonardo da Vinci is universally known by his remarkable picture of the "Last Supper," engravings of which may be found in every part of the civilised world. That wonderful production was painted by him for the refectory of a convent at Milan, and was, it is said, the first picture he painted in oil; and a pretty mess he made of it, for the picture about the middle of the sixteenth century began to perish, in consequence of some defect of his making up of this then new medium, or vehicle, as it is called. The picture, however, had been previously so much admired that several copies had been made of it; and it is from these copies that the engravings, with which we are so familiar, have been executed. One of the best of these copies was painted in the year 1510 for another convent, and was finished when the original, which is now almost totally decayed, was in a perfect state. This copy was purchased by Sir Thomas Lawrence, and is in the Royal Academy. It is a much better criterion of what the original was than the original itself, which has been repaired, as it is called, by inferior artists, who, it has been said, have left nothing of the picture but the heads of three of the apostles, and these are now very indistinct. I have myself seen the picture, which is at the end of a dull-looking, gloomy hall, and can only be very imperfectly seen, the custodian of the chamber furnishing you, for a small gratuity, with "aids for development" of the work, in the shape of binoculars, which are greatly needed. A very amusing description of the picture, and of the circumstances under which it is exhibited, will be found in that most humorous work, the *Innocents Abroad*, and I can vouch for the accuracy of the representation there given of the picture and its surroundings.

Michael Angelo was a contemporary of Leonardo, and there seems to have been a considerable jealousy felt by the latter of the former. They were each employed to paint a picture for the council-hall in a Florentine palace. The pictures were to have been in fresco, one at each end of the hall, and it is said that although Leonardo composed the cartoon, or "sketch on paper," from which his picture was to be painted, he was so jealous of Michael Angelo, then a much younger artist, that he would not go on with the work. Vasari pronounces the two cartoons prepared for these intended pictures as being sufficient to form a school of art for the world. Unfortunately, they were both destroyed a few years after they were produced. Leonardo, who seems to have been very sensitive, easily offended, and capricious, died, after a somewhat adventurous life, in the year 1519, when he was 67 years old, leaving a large number of works which distinguish him as one of the finest artists the world has produced. Michael Angelo's renown is as great, if not greater, than that of Leonardo. Michael Angelo first distinguished himself as a sculptor, and was remarkable for his great anatomical knowledge, which he was particularly fond of displaying in his sculpture and in his painting, leading him often into violations of good taste and into gross exaggerations. The work by which Michael Angelo has established a fame that seems likely to endure to the end of time, is his series of fresco paintings in the Sistine Chapel, in Rome, executed by the command of Pope Julius II. Michael Angelo was very diffident of his abilities as a painter, and tried to evade the execution of the Pope's command, strongly urging him to employ Raffaelle, as better qualified; but Julius would not be put off, and insisted on Michael Angelo setting to work. It is said that these were the first frescoes he had ever executed, and so timid was he in proceeding that, after drawing the cartoons, or paper sketches, he sought the aid of some of his fellow artists to execute the frescoes; they, however, so bungled the work that Michael smashed up all they had done, and executed the whole of the frescoes with his own hand, a work he accomplished with wondrous rapidity. In twenty months the whole of the ceiling frescoes were finished. The Sistine Chapel is an oblong building, 133 feet in length, 43 feet in width, and 58 feet in height, and is reserved especially for the use of the popes. The ceiling frescoes, and the great fresco painting of the "Last Judgment" subsequently painted by Michael Angelo on the altar wall of the chapel, are regarded with the deepest reverence. They are the subject of earnest contemplation by art students, and many a visit has been made to Rome for the sole purpose of contemplating these frescoes, and those of Raffaelle in another part of the Vatican, with which the Sistine Chapel is connected. Raffaelle was born in 1483, a few years after Michael Angelo, and died at the early age of 37. He covered with painting, in fresco, four apartments in the Vatican, which are called at the present day by his name, and have been and are visited by artists and lovers of art from every part of the world. Many works have been published giving full descriptions, accompanied by engravings, of these celebrated frescoes. Raffaelle, however, is better known to our countrymen by what are called "the cartoons," of which engravings numberless have been produced. The history of these cartoons is so remarkable that I cannot pass it over. A cartoon is a large outline on paper, with a very slight amount of shading, painted in monochrome, or one colour, from which a picture is to be afterwards painted in fresco, or worked in tapestry. Certain tapestries were required for the wall of a portion of the Sistine Chapel, reserved for the special use of the cardinals. Raffaelle was employed to design these tapestries, ten in number. Ten cartoons were drawn, and the tapestries worked from them are now in the Vatican; but the cartoons from which they were worked seemed to have been altogether neglected and uninquired after for many years. Seven of them were afterwards found by the celebrated Rubens, at Arras, where great tapestry works were fabricated, and he induced our Charles I., a patron of his, to purchase them. After the decapitation of Charles, they were, at the suggestion of Cromwell, purchased for the nation at the price of £300, and ultimately found their way to Hampton Court Palace, from whence they have now been transferred to the Kensington Museum. The best means of judging of these cartoons are to be found in a series of large photographs, of which copies are in this building; they are fac-similes of the original, showing the rough treatment they received since they left the artist's hand, as well as the true spirit of the artist's conception, which no hand-engraving could adequately convey.

From this period, which is called the Renaissance, art became disseminated and established all over Europe, and the different countries produced leading artists, each of whom had many followers. The works of these artists and their followers constituted what are called, in art parlance, "schools."

It is unnecessary for me to describe at great length these schools, since every particular relating to them, and the names, principal works, and characteristics of their followers, are to be found tabulated on the walls of our Gallery on charts, which contain in themselves a condensed history of painting. We are indebted for these charts to the energetic and enthusiastic President of this institution (Sir Redmond Barry), who will hereafter be acknowledged in the history of our colony as the man who the most earnestly promoted its creation, and who watched over its progress, from the laying its first stone, with an interest and devotion to which was entirely owing its early prosperity.

Correggio and Parmegiano were the representatives of the school of Lombardy; of the Venetian school—Titian, Giorgione, Tintoretto, and Paul Veronese. Tintoretto painted the largest oil picture in the world, which is to be seen at Venice, being 74 feet in length by a height of 30 feet. Paul Veronese painted one 30 feet wide and 20 feet high, which is in the gallery of the Louvre, where I have seen it with a crowd of artists before it copying, some the whole (of course on a small scale), and some merely portions of it; and very much interested I was, although they did a little obstruct the view of the pictures, in watching them as they seemed to be devouring it with their eyes, some perched up upon scaffolding formed by a plank placed upon the steps of two double ladders, without the assistance of which they could not examine the beauties of the higher portions of the picture. Van Eyck is considered the leading artist of the Flemish school. Quentin Matsys belongs to it, who, it is said, was a blacksmith, and became a painter to propitiate a painter, with whose daughter he fell desperately in love, and whom he afterwards married. Although called a blacksmith, he was really a designer of ornamental ironwork, and was as much an artist in that particular kind of work as the celebrated Benvenuto Cellini, whose works have now an almost priceless value. As immediately introductory and leading into the English school—or what I choose to call the English school, for I believe English art has not yet had this distinctive appellation authoritatively given to it—I will say a few words upon the school of the Netherlands, to which belonged Rubens, Rembrandt and Vandyk. Rubens was born in 1577. His works are so celebrated and so well known that it is scarcely necessary to speak of his artistic power. One of the longest galleries in the Louvre is covered with his works, and our National Gallery is rich in specimens of his skill; but his greatest work is at Antwerp, where he studied painting and lived the greatest part of his life. It is in the cathedral there; the subject, the "Descent from the Cross;" and the picture is copied by almost every student who visits the Continent for improvement in his profession. Rubens visited England and was largely patronised by Charles I., as also was Vandyk, who painted the portrait of that monarch. Vandyk, the pupil of Rubens, in the opinion of many, and I am one of the number, surpassed his master, although his principal pursuit was portrait painting. There is a very large number of his works in England, and two or three fine specimens in the National Gallery. Rubens and Vandyk were followed by Rembrandt, who certainly surpassed both of them, and introduced a completely new style of painting constituting the "School of Rembrandt." Of Rembrandt's work we have some magnificent specimens in the National Gallery. Rembrandt never visited England, but his works found their way there. The celebrated Gerard Dow, Meiris, Metzu, Linglebach, Teniers, Wouvermans, Ostade, Paul Potter, Vandervelde, Rusydael, Berghem, Both, and Carl Du Jardin, all belonged to that school, and we have fine specimens of the works of all these artists in our national collections.

To the production of the artist school of the Netherlands may be traced, as I think, distinctly, the creation of a love of art in our own country, and, as its consequence, the progress of art among ourselves. There is so little evidence of our having taken any interest in art before the time of Henry VIII., that up to the time of that monarch it may be said that we had no art history. The first painter of eminence who came among us was Hans Holbein, a native of Switzerland. He came to England in the year 1526, and remained until his death, which took place in the year 1554. He was little more than a portrait painter, and was largely patronised by Henry VIII., of whom he painted several portraits. A large number of his pictures may be seen at Hampton Court, and as portraits of eminent persons of the day some of them are exceedingly interesting, though their accuracy as portraits can scarcely be trusted to. Of painting, it is said by Aristotle, imitations must be either superior, inferior, or equal to the model; and he praises Polygnotus, because he painted men (and I presume women) better than they were. On this principle, I presume he would have been delighted with Holbein, who seems to have been a flatterer in his portraits, and a pretty deal of mischief this flattering occasioned. Holbein was sent to paint a portrait of Anne of Cleves, that Henry might be able to judge whether he should like her as a wife. Holbein drew so flattering a portrait, that Henry made up his mind she "would do," and had her brought over to England, when he found her not at all equal to sample; but was, nevertheless, obliged to complete the contract. Henry, who was horribly disgusted, visited his indignation, not upon Holbein, but upon his minister (Cromwell), who had recommended this portrait-taking arrangement; and who ultimately lost his own head because Holbein had not correctly copied that of Anne of Cleves, a head which, upon canvas, might have been regarded as a portrait of Venus, but which Henry declared to be in reality like that of a Flanders mare.

Our First Charles was also the first real English patron of art. He caused not only Rubens and Vandyk, but other artists, to visit England. At Rubens's suggestion, he purchased the cartoons. He formed a very valuable collection of pictures, all of which were afterwards sold or dispersed. The Puritan Parliament gave directions that all pictures in which there was a representation of the Saviour, or the Virgin Mary, should be burnt. After the restoration, many of the pictures were returned to the royal collection in the Palace of Whitehall, where they were destroyed in the great fire, which consumed the whole of the palace, except the banqueting chamber, which still fronts Parliament-street, nearly opposite the Horse Guards.

Notwithstanding the taste that was created for art at that time in England, its immediate effect with us, like the creation of a taste for art in Italy by the introduction of Grecian painting and Grecian painters, was not at first to bring out native talent, but to gratify itself by the acquisition of foreign works. There is also a curious parallel between the progress of art in our own country and in Italy. Soon after the feeling for it was created there, the Iconoclasts sprung up, who repressed its progress for a time with us. After Charles I. gave it birth in England the Puritans came into power, and in the most ruthless and bigoted spirit struck down, as far as they could, everything that was its offspring. Charles II. was a lover of learning, fancied himself perhaps a lover of art, and professed to encourage artists; but his taste was very effeminate and frivolous, and he encouraged the production of most ingenious absurdities in the decoration of ceilings, staircases, &c., which were covered with what was called classical productions from the pencil of one Verrio, whose works are still to be seen in many of the old mansions. Dickens, in *Bleak House*, describes one of these ceilings in a mansion in Lincoln's Inn Fields, occupied as chambers by Tulkinghorn, the lawyer, and which he makes the scene of the lawyer's murder, describing the figure of a Roman introduced in the painting as pointing down from the ceiling on his lifeless corpse. Sir Peter Lely, however, appeared in England about this time, and is thought by some to have approached nearly to his immediate predecessor, Vandyk. Most of the mansions of our old families have some portrait from his easel; and he is well known as the great painter of what were called King Charles's beauties. He was followed by Sir Godfrey Kneller, who practised his profession in the reign of

Charles II., and during the reign of the five succeeding monarchs. The first true historical painter of our own country was Sir James Thornhill, who was employed in the decoration of the dome of St. Paul's and of Greenwich Hospital; but was paid in a very undignified manner—viz., at the rate of 40s. per square yard. After his death art seemed to retrograde for a time rather than progress, although there was a painter of the name of Richardson, who wrote a work upon art, showing the highest feeling for it, and laying down principles which have authority at the present time. He himself, however, had not skill sufficient to demonstrate their value, and it is said by Sir Horace Walpole, at the commencement of the reign of George I., art in England had fallen to its lowest ebb.

Richardson died in the year 1745, leaving behind him an artist of some celebrity in the person of his son-in-law, one Hudson, whose celebrity, however, as an artist is completely merged in that of his pupil, the illustrious Sir Joshua Reynolds, who may be said to head the list of the names which will hereafter give England a position in art little lower than that which she has taken, and which we trust will ever occupy, in science and in all those mental achievements which constitute the true glory of a people.

Cotemporaneously with the appearance of Reynolds, there shone forth a genius of another character, that of Hogarth, who was originally apprenticed to an engraver, but raised himself to the rank of one of the first painters in a style which he originated, but which has never been followed or since entered upon. He married the daughter of Sir James Thornhill, who was at first deeply wounded at what he considered the degradation of the alliance. It took some years to reconcile him to the match, and the first step towards the reconciliation was effected by Lady Thornhill procuring one of Hogarth's pictures, and placing it secretly in Sir James's dining-room. "Whose painting is this?" he exclaimed, with delight. "Hogarth's," replied his wife. He rose up much agitated. "Very well, very well," said he; "the man who can paint like this can maintain a wife without a portion." A perfect reconciliation, however, very soon followed. Hogarth's life is one of the most interesting in the biography of art; but I must take leave of Hogarth to return to Sir J. Reynolds, who was about thirty years Hogarth's junior. He was born in the year 1723, three months before the death of Sir Godfrey Kneller. His father was a clergyman, who was by no means gratified at the taste his son showed for drawing, and marked his sense of his son's genius by writing on one of his early productions, "Done by Joshua out of pure idleness." His strong love for art, however, could not be repressed, and ultimately he was placed under Hudson as a pupil, and soon progressed so rapidly that Hudson became jealous of and got rid of him. He had, however, attracted the notice of Captain, afterwards Lord Keppel, who took him with him on an expedition which enabled him to visit many places in Europe, where he saw works of art of the highest character, and procured him so much patronage that he was enabled to gratify the earnest desire of his heart—viz., to visit the Sistine Chapel. To his amazement, when he came into the presence of these glorious frescoes, of which he had heard and read so much, and by which he expected to be entranced with admiration, he found himself perfectly unmoved. In one of his letters he thus refers to this moment of his life:—"It has frequently happened, as I was informed by the keeper of the Vatican, that many of those whom he had conducted through the various apartments of that edifice, when about to be dismissed have asked for the works of Raffaelle, and would not believe that they had already passed through the rooms where they are preserved, so little impression had these performances made on them. I remember very well my own disappointment when I first visited the Vatican, but on confessing my feelings to a brother student, of whose ingenuousness I had a high opinion, he acknowledged that the works of Raffaelle had the same effect on him, or rather that they did not produce the effect which he expected. This was a great relief to my mind, and on inquiring farther of other students, I found that those persons only who from natural imbecility appeared to be incapable of ever relishing these divine performances made pretensions to instantaneous raptures on first beholding them. I did not for a moment conceive or suppose that the name of Raffaelle, and those admirable paintings, in particular, owed their reputation to the ignorance and the prejudice of mankind; on the contrary, my not relishing them, as I was conscious I ought to have done, was one of the most humiliating things that ever happened to me. I found myself in the midst of works *executed upon principles with which I was unacquainted.* I felt my ignorance, and stood abashed."

Reynolds remained in Italy three years, and on his return to England found himself subjected to a criticism and a jealousy which for a time gave him considerable pain. His old master, Hudson, when he looked at his pictures, exclaimed, with an oath, "You don't paint so well as when you left England." But the contest with his fellow-artists was of short continuance. His fame soon spread far and wide, and brought him into association with Dr. Johnson, who formed a strong friendship for him, which continued until the close of life. This is the more remarkable, as Johnson evidently considered artists a rather inferior class of persons; nor did he greatly admire actors, although Garrick was one of his associates. Sir Joshua painted a portrait of Johnson, in which he represented him as reading with the paper close to his eyes, showing he was near-sighted, at which he was very angry. "Sir," said he, "it is not friendly to hand down to posterity the imperfections of any man." Mrs. Thrale tried to pacify him by telling him he would be known to posterity by his talents, not by his defects; and remarked that Reynolds, in painting his own portrait for her, had introduced his ear-trumpet, showing he was deaf. "Madam," said Johnson, "he may paint himself as deaf as he chooses, but I will not be painted as 'blinking Sam.'" The great event in Sir J. Reynolds' life, and which is now exercising, and always will exercise, an immense influence upon art in our country, and, indeed, throughout the world, was the establishment of the Royal Academy. In the year 1760 the first public exhibition of works of modern painters, sculptors, and architects took place in London, and has been truly described as one of the most memorable events in the annals of modern art. Its success was immense, and led to a second exhibition the following year. Johnson described it as "an exhibition by which the artists please themselves with the multitude of spectators, and by imagining that the English school will rise much in reputation." He says, "Surely life, if it be not long, is tedious, since we are forced to call in the assistance of so many trifles to rid us of our time—of that time which can never return." Johnson, however, though he thus contemptuously alludes to the exhibition, wrote a preface to the catalogue of the third exhibition, at which a charge of one shilling was made to every person for admission, in order to check the thronging of the exhibition with crowds, who prevented any from examining the works exhibited with comfort to themselves. Reynolds contributed to these exhibitions, which ultimately became merged in, or rather gave rise to, the present Royal Academy in the year 1768, of which Reynolds accepted the presidency, at the express request of George III., who had previously conferred upon him the honour of knighthood.

It was in the year 1780 that the yearly exhibitions first began at Somerset House. Between the year 1768 and that year the exhibition had produced about £1500 yearly; in 1780 the receipts reached £3000, and they may be said to have gone on increasing up to the present time, the exhibition now, as I suppose you all know, taking place on the first of May in every year, in a gallery lately specially erected at Burlington House, Piccadilly—the National Gallery, Trafalgar-square, having been found, in many respects, unequal to the requirements of our yearly national exhibition.

The influence of the Royal Academy upon art, and the immense benefit it has conferred upon its professors, it would be difficult for me to do justice to, even were I to devote a whole evening to the subject. I have not time now even to describe generally all its objects. It is an association consisting of forty academicians, being painters, sculptors, or architects; A second order, called associates, being twenty in number, from which the vacancies in the academicians are supplied. The academicians elect the members of their own body, but their election must be ratified by the Crown. There are also six associate engravers, elected by the academicians from those exhibitors of engravings who declare themselves candidates. There are several other officers and professors, all of whom are either nominated by the Crown, or elected by the academicians, and approved by the Crown; and these professors have to deliver lectures to the students. There are schools for study from casts, from living models, and a painting school. All painters, sculptors, and architects are admissible as students upon showing reasonable indication of talent, the specimens of their works being received anonymously; and all are allowed to exhibit their works at the annual exhibition, if their works are sufficiently artistic not to excite ridicule, and there be room for their reception—many works being now unable to obtain a place, in consequence of the large number sent for admission. If any artist evinces great talent, he is chosen as an associate, as vacancies occur, and ultimately becomes an academician, or R.A., as it is called—an addition to an artist's name which is a sure guarantee of considerable ability. The arrangement of the pictures at the annual exhibition is settled by a committee called a hanging committee, and every year there are as many discontented artists as would suffice to hang up every member of the committee himself in *propriâ personâ*, which would probably be done were not the dissentients restrained by the terrors of the law or the precepts of Christianity.

Of this academy Reynolds was chosen president, and continued in office for 21 years. During that time he delivered his celebrated discourses, 15 in number, which constitute one of the text-books of modern art.

The history of painting in England, from the formation of the Royal Academy, may be traced in the catalogues of the yearly exhibitions, all of which, from the first to last published, are to be found on the shelves of our Public Library. The first catalogue shows only 136 works, and the only artists of note that exhibited were Angelica Kaufman, West, Zucarelli, Bartolozzi, Wilson, Gainsborough, Bacon, the sculptor, and Sir Joshua Reynolds. Some of the exhibits seem to have been very unimportant affairs. One Michael Angelo Rooker contributes two works of art, which he describes as "stained drawings." Wilson sends three pictures described as "landskeps," with the old form of spelling, whilst Gainsborough adopts the more modern word landscape. The number of exhibits increased from year to year very rapidly, soon occupying the whole of the available space at Somerset House; and from that time the number of pictures sent for exhibition has always been largely in excess of the powers of representation. This has led to a great number of subsidiary yearly exhibitions by persons associated together under different titles, such as the Society of British Artists of Painters in Water-colours, and others.

The history of painting in England, from the formation of the Royal Academy, may be traced in the catalogues of its yearly exhibitions. Cotemporaneous with Reynolds were, in addition to the artists I have mentioned, Barry, Opie, and Fuseli, all of whom delivered a series of lectures at the academy. Since Reynolds's time there has appeared so vast an array of artists, whose works will live to all time, that I will not mention any, lest I should appear to consider those mentioned as superior to a large number quite equal to them in talent, but to whom time will not allow me to refer.

Before closing my lecture, I will make a few remarks upon what may be regarded as our own art prospects. That we have a great deal of talent, trained and untrained, was evidenced by the exhibition of colonial artists that took place last year, not far from this lecture-room. Many of the pictures would have graced the walls of the galleries of the Royal Academy, while some would most undoubtedly have never been permitted to appear upon them—some showing what genius can produce when carefully trained, others what vagaries it can indulge in when it works without guidance.*

Without going so far as Cennini, whose course of study, spreading over about 13 years, I have brought under your notice in a former part of this lecture, it is quite certain that no one can advance surely in the path of art who does not move on slowly, considering well the effect of every step, and ever keeping in his mind the highest examples of art that he has been privileged to look upon. We have here in our galleries some specimens of painting which a friend, whose judgment is worth having, and who has lately returned from England, assures me will compare favourably with any pictures to be found in the yearly exhibitions in London. That in our gallery to which we have given the name of the "Dancing Girl" has been reproduced by the artist, and is exhibited this year in the Royal Academy Exhibition, under the title of "A Question of Propriety," with a reference, not to a passage in Longfellow's poem of the "Spanish Student," of which we have assumed it to be an illustration, but to "Annals of the Inquisition in Seville, 1627." This repliqua is not an improvement on our picture, still it excites in England as much admiration as that we bestow upon our own. This picture and several others, including those of Von Guerard, Buvelot, and Chevalier, are sufficient to create a standard of art of a very high description; and without such a standard before them, our art-students would be injured rather than benefited by admission to the gallery for the purpose of study. We have, in addition, excellent casts of the most beautiful works of sculpture that are to be found in Europe, and the efforts of our art-students to emulate these examples of painting and sculpture are guided by skilful instructors, Messrs. Von Guerard and Clark, themselves artists of great ability. Of the talent of our students we have unmistakable proofs in the result of their labours, showing that the average ability of the small band of students to be seen at work in our gallery is not below the European standard. I have watched copyists in the galleries of Europe copying with a fidelity which would have made it difficult to distinguish the copy from the original; yet I say that there is a lady student in our gallery who would have no reason to shrink from a trial of skill with any copyist I have ever seen at an easel.

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* Since this lecture was delivered there has been a second exhibition, so vast an improvement upon the first as to justify the belief that our Australian pictures will in a very few years compare as favourably with those produced by the artists of the mother country as do our fruits and flowers with their counterparts in our native land.

I believe that in future years Australia will resemble Italy in its art characteristics as closely as it now resembles it in its climate. I believe, moreover, that, when we have a larger and a more leisure population, art will be as warmly patronised here as it has ever been in countries where wealth has been combined with leisure for its enjoyment, and taste and education have guided its expenditure.

I must now bring my present lecture to a close. I have endeavoured to give a general outline of the history of painting, tracing it from its first appearance as an art down to our own days. It is an art which has always attracted to it the highest minds, and has always taken a deep hold upon the feelings and sympathies of mankind. It constitutes a language, which all can interpret, for communicating ideas of the noblest character—a universal language grander than that of poetry itself. It presents nature in her most attractive garb, and under her most sublime aspect, and brings before the eye and stamps upon the heart scenes, events, and feelings which arouse within us emotions which may leave their influence upon us for good while life endures.

THE GROWTH OF LANGUAGE.

A LECTURE,

DELIVERED BY M. H. IRVING, M.A.

(Head Master of Wesley College, late Professor in the University of Melbourne),

On 16th NOVEMBER, 1871.

MR. CHAIRMAN, LADIES AND GENTLEMEN—

ABOUT a year ago, one of the organs of public opinion in this city took me severely to task, and threatened me with divers awful consequences, because I, then filling the position of professor in the University, could find it possible to spend a little of my leisure in helping with my poor judgment to select a crew to represent the University of Melbourne in friendly rivalry with her sister of Sydney, but had refused to lecture on Technology, because I was too busy. Of course I laid the rebuke to heart, conscious that in some mysterious way it was deserved; although in the first place I hadn't been asked to lecture on Technology, and in the next place, if I had been so desired, I should not have known how. But when my friend, our worthy chairman, who is heart and soul devoted to technology, and under whose guidance I trust to have my crass ignorance enlightened, and do my little possible on its behalf, asked me for a lecture in this course, I willingly consented, being assured by him that I might select any subject of general interest, and that my lecturing here to-night was quite compatible with very slender acquaintance with art pure, art manufactures, or technology.

I am a profound believer in the good old maxim, "*ne sutor supra crepidam*"—let the cobbler stick to his last; and, therefore, in place of getting up something I did not know, wherewith to trespass on your attention to-night, I have ventured to choose a subject with which I have been for years necessarily somewhat familiar, and to which, like many other common things around us, we are prone perhaps to pay but little heed—Language, that wondrous offspring and handmaid in one of human thought. "*Omnia exeunt in mysterium,* as some one says; or if he doesn't, he ought to have said it" (I quote from Charles Kingsley's philosophic artist); and of all the mysteries that lie around us from our cradle to our grave, always saving the mystery of life itself, I know none so passing wonderful as this mystery of language.

Whence came it? Whither tends it? Whence this strange vital tenacity of its own? Generations that use it flow and ebb like the tide, and are known no more; but language abides, worn it is true by their use, but as little destroyed thereby as the rocks that are fretted by the ever-recurring tide of ocean. It seems to each of us but a part of himself, something he can make or unmake. Can he? Which of us here present has given to our English speech one new word? which of us can take from our mother-tongue one single word, and bid it be no longer? If we made it, verily it is stronger than we.

And yet, in a sense, man did make language as much as he has made aught else that is his. Man can *create* nothing; he must have somewhat given him first to work upon, and all our technology, I take it, is but studying how best we may modify that somewhat given from elsewhere—be it language, whereto entrusted, noble thoughts live for ever; or the marble of the sculptor, wherein form divine abides imperishable; or the pigments of the artist, whereby beauty of colour as well as grace of form gladdens our eyes; or the marvellous wealth of elementary substances that nature scatters around us in profusion, and the chemist's art teaches us to modify and recombine for the delectation and comfort of our material life.

Whence came language, in its very simplest type? Some hundred years ago, when the doctrine that man is the measure of all things was even more in vogue than it is now, one set of philosophers gravely propounded the doctrine that men met, and in solemn conclave assembled did then and there pass their act of *parliament*—for parliament you know means only *speech* (a meaning sometimes too significant)—and gave to each thing its appointed name, to every act its proper verb, to every quality its fitting adjective. A pretty fancy, in faith, but one which hardly commends itself to us! For how, ere this agreement of the people, did the individual paterfamilias signify his wants to his spouse, his orders to his children, if language was not ere this solemn act of uniformity? And, if we waive this difficulty, how did the delegates who formed language argue, discuss, divide, and determine, if language was not yet? No, we can as little believe that man existed without language, as we can that he ever existed without thought—"like the beasts that perish." But, though we reject this, the theory of Maupertuis and the Berlin Academy, we may as little give credence to the opposing view, that his Creator endowed man at the outset of his career upon the earth with a full and completely organized language; for such a theory, besides being opposed to all the history of linguistic development, so far as we have it in our possession, is *à priori* absurd. It supposes the mind of man stored with words, the symbols of notions, which as yet had been called forth by no experience. Rather should we believe that the words, as well as the thoughts, rested only potentially in the human mind, ready to be called into being so soon as needed; that He who gave to man the power of observing, of analysing his sensible impressions, of forming out of the multiplicity of individual objects around him general notions, and so classifying and reducing to order what must at first have seemed an infinite chaos, gave him also, therewith, the power of first attaching names to the individual objects, and then extending these to classes: the process of nomenclature corresponding precisely to, and synchronizing with, the progress of thought.

But what determined the special sign, the peculiar sound, which should come into being when man came in contact with some individual thing, or generalized from it? Why, for instance, should the root *sta-* be indissolubly bound up in our own language, and the large family akin to it, with the thought *stand*, verb or noun, it matters not which? Why should the sound *re-* be appropriated to smooth, swift motion, as in the Latin *rivulet*, or the simple English *run?* or why, again, should *sed* in Latin, *sitz* in German, *sit* in English, all denote the same posture, as when we might speak of a sedentary sitting in a sitz-bath, using words belonging to all of the three kindred tongues. I cannot answer the question, nor do I believe it ever will be answered. Perhaps, with regard to two of my instances, you may say that it seems to you that the sound of *sta-* suggests naturally the thought of fixity, of motion arrested, of unyielding resistance, even of solidity; and tell me, what is perfectly true, that you find them severally, in *stable*, in *stay* or *stop*, in *stubborn*, and in *stuff*, our old English word for what we now commonly call matter. And again, you might say as to the use of the radical *re-*, that the very roll or trill of the *r* which begins it suggests the idea of smooth, onward gliding. I cannot say it is not so, and your theory would come very close to the doctrine of phonetic types, first set forth in English in Max Müller's celebrated series of lectures on the "Science of Language," a view embodied in a passage which I shall venture to quote:—"The 400 or 500 roots which remain as the constituent elements in different families of language are not interjections, nor are they imitations. They are phonetic types, produced by a power inherent in human nature. They exist, as Plato would say, *by* nature, though with Plato we should add, that when we say by *nature*, we mean by the hand of God. There is a law which runs through nearly the whole of nature that everything which is struck rings. Each substance has its peculiar ring. We can tell the more or less perfect structure of metals by their vibrations, by the answer which they give. Gold rings differently from tin, wood rings differently from stone, and different sounds are produced according to the nature of each percussion. It was the same with man, the most highly organized of nature's works. Man, in his primitive and perfect state, was not only endowed like the brute with the power of expressing his sensations by interjections and his perceptions by onomatopœia; he possessed, likewise, the faculty of giving more articulate expression to the natural conceptions of his mind. That faculty was not of his own making. It was an instinct of the mind as irresistible as any other instinct. So far as language is the production of that instinct, it belongs to the realm of nature. Man loses his instincts as he ceases to want them. His senses become fainter when, as in the case of scent, they become useless. Thus, the creative faculty which gave to each conception, as it thrilled for the first time through the brain, a phonetic expression, became extinct when its object was fulfilled. In the beginning the number of the phonetic types must have been almost infinite." In the case of certain sounds, as we have just observed, we may fancy that we, too, can recognize even now the original thrill of thought that caused the word to spring to life; but these are few and far between, and for the most part we can find no clue to the lost link of connection between thought and speech. Why, for instance, should *mah* in Sanscrit, *mag* in Latin, *much* in English, all denote great, or why should the sound found in our English *mill* be in every European language appropriated to the act of grinding? Yet, though the theory of phonetic types shadowed forth in the passage I have quoted can be distinctly traced in but few instances, it seems infinitely preferable to its two rivals, to which, in the passage quoted, Professor Max Müller somewhat slightingly adverts, which he almost cruelly nicknamed the pooh-pooh and the bow-wow theories, or, as their votaries more respectfully style them, the interjectional and onomatopoetic theories of language.

As each of these finds numerous and eager supporters, it may be well briefly to advert to them. The interjectional would derive all language in the first instance from those involuntary utterances whereby men express the feelings which they themselves experience when brought suddenly into contact with various kinds of objects. For instance, the advocate of such a view would maintain, as, indeed, Mr. Wedgwood in his English Dictionary does maintain, that all such words as *foul, filthy, fiend,* are immediately derived from the interjection *fie* or *faugh*, whereby we express our instinctive abhorrence at aught repulsive; that *huge* and *ugly* are similarly due to the guttural *ugh* of disgust; *wail* and *weep*, to the plaintive utterance of "*woe*." The onomatopoetic, again—I must apologise for this long Greek word, but I cannot help it, for there is no precise equivalent for it in English; perhaps, however, I might use imitative for it—the imitative theory, then, says that man, hearkening to the diverse sounds around him, produced whether by animate or inanimate nature, was led to name from these the individual objects that produced each several noise, or the sound itself; and would point in confirmation of their view to such words as *crow*, *croak*, or even *raven*, originally *hrafn*, wherein they would say we can yet hear the harsh cry of the hoarse bird; or, again, to the Latin *ulula*, the English *owl*, as imitative alike of the tu-whit to-whoo of the melancholy bird of night that to the moon complains from her ivy-mantled tower; and would point triumphantly to such names as the English whippoorwill and peewit, or our Australian mopoke, in which we cannot for one moment doubt that the name is directly taken from the note. Or turn, they would say, to your verbs; what plainer imitations can you ask for than the *drop*, *drip*, or *drizzle*, whereby you express the action of water falling, with a greater or less volume, and consequent intensity of sound? What are you doing, but imitating as best you may the sound you hear, when you speak of the tinkling cymbal, the babbling brook, or the plashing fountain; the din of battle, and the clashing of swords; the clank of chains, the rattle of musketry, or the roar of the thunder. We are compelled to admit that the advocates of each opinion can make out a strong case, can cite many words which are on their theory clearly explicable; but we cannot accept either as sufficient to explain *all* the roots of language. In fact, it might be a sufficient answer to the first to say, that not all, in fact very few, natural objects are such as to call forth in the observer feelings so strong as to require the relief of an interjection outcry; and to the latter to point out that earth has indeed her many voices, yet sound is not by any means a universal characteristic of the objects around us, still less of those glorious objects set in the heavens above us, whereunto man must early have looked up, and for which he must have found names; of which Addison well wrote—

> "The spacious firmament on high,
> With all the blue ethereal sky
> And spangled heavens, a shining frame,
> Their bright Original proclaim.
> What though no real voice or sound
> Amid their radiant orbs be found,
> In reason's ear they all rejoice,
> And utter forth a glorious voice,
> For ever singing, as they shine,
> 'The hand that made us is divine.'"

I have thus endeavoured briefly to put before you the competing theories of the origin of language, and have indicated that which to my mind most commends itself, though I am bound to admit that, like its rivals, it is not able to give in all points a satisfactory account of itself. Thus much seems clear, that the very earliest development of vocables or phonetic types, if we take Max Müller's word, was spontaneous, and not a deliberate, considered manufacture. So little able are we, "the heirs of all the ages, and the long results of time," to carry ourselves back in imagination to the state of mind of our earliest ancestors when brought face to face with the world around them, that we find a grave controversy among philosophers as to the import of these primeval words. Quoth one authority, "It is perfectly clear that the earliest word must have been the noun, the name of this or that thing." Quoth another, "Nay, I claim higher antiquity for the verb, the name of action, for things are distinguished from one another only by motion or change. Were the universe at rest no one part could be recognised as diverse from another." Who shall decide when doctors disagree? Let us be content simply to say we can as little imagine language, as a means of communication of thought, existing with nouns alone, as we can, on the other hand, think of it as made up entirely of verbs; and directly it arose from the merely conversational into the narrative stage we can see that it must have attained to the distinction of pronouns, *me, thee, him,* or *that,* denoting severally the speaker, the person addressed, and the subject of the talk. And besides these three classes of words or parts of speech, a fourth must very soon have taken its origin in the simpler adjectives, expressing the obvious, plain distinctions between objects otherwise similar, such as *large* and *small, many* and *few, bright* and *dark, strong* and *weak.* And to these must early have been added the simpler prepositions, indicating the common relations of place and time, such as *in, of, at, by;* the simpler prepositions I say, for many of the so-called prepositions are fragmentary relics of fuller words. Such, then, may have been what Plato would have called the ἀναγκαιοτάτη γλῶσσα, language in its scantiest, most rudimentary, most absolutely necessary stage.

Next followed, in the languages akin to our own, the inflectional stage, a stage in which all the powers of man's intellect must have been given to perfecting, as a means of communication, that language whose origin had hitherto been spontaneous; to the devising of all manner of terminations and modifications of original words, to express the manifold relations of things and actions to one another; the stage in which were developed all the full systems of verb conjugation, and of noun declension, as we find them in Latin, or richer yet in Greek, more perfect still in Sanscrit; the stage wherein single words are made to convey as full a meaning as possible, commonly known as the Synthetic, or putting together, type of language.

After this followed a reaction, which has left the languages of modern Europe what the bulk of them now are, comparatively bare and destitute of inflections, expressing by separate words as far as possible all those manifold varieties of meaning which changes on single words previously conveyed, a stage whose utter contrast to the foregoing one single example will show as clearly as a hundred. Where a Roman said but one word, *amaverimus,* we must, to express his meaning, use four, and say *we shall have loved,* employing one word *we* for the name of the agent, *shall* to indicate futurity, *have* for the perfect tense, and *loved* to name the action performed. We are not, as you will doubtless observe, perfectly analytic, or picking to pieces in our mode of speech, for we still retain the inflectional *ed,* which, appended at the end of the verb *love*, gives us what we all know as the passive participle.

And corresponding to this loss of inflections, but in time preceding it, is the loss of power of calling forth new words for the expression of new thoughts. The cause of this loss is, I suppose, embodied in the old adage, "familiarity breeds contempt;" and the strong feeling which at first coined words in rapid profusion from the mint of thought soon grew cold and inappreciative, and language passed as regards its names into the stage in which we now find it, which we might call the manufacturing stage, when for a new object no *new* name is found, distinct from and unlike the old one, but some modification or combination of the existing word-wealth of the language is formed to meet the exigencies of the case. A couple of instances will show you what I mean. Time was a little before the Christian era, when the cherry was a new tree at Rome, brought from the East. But the Romans did not give to this unknown object a name also hitherto unknown. They asked, "Whence comes it?" And being told from Cerasūs, a town on the Black Sea, they straightway gave it that name, changing only the declension of the word for distinction sake, and so the old name henceforth did double duty for place and fruit. That was a modification; now for an example of a combination. A hundred years, or even less, ago it was a new thing for men to see lines of squared wooden rails laid along a roadway to lessen the friction of the waggon-wheels. What shall this new thing be called? It is a way, a road, no doubt of that; let it keep its name, but with a difference—and what difference? Just as, in the case of the cherry-tree, the Romans might have asked, not "Whence came it?" but, "Who brought it?" and their question answered, have bidden it be known henceforth by the name of its acclimatizer; so in this case English people asked, "Whose idea is this?" And finding that the invention was due to Mr. Outram, owner of an extensive colliery, straightway did they diffentiate road or way by the prefix of his name, and the new thing took the name of Outram-way, or Outram-road, which ungrateful posterity, forgetful of its benefactor, and mindful only of its own convenience, has elipt to our modern tramway or tramroad.

I desire to dwell a little on each of the four states of language to which I have thus briefly called your attention, and to bring under your notice some illustrations of each. These I shall endeavour mainly to draw from English and from Latin, with which we are most of us familiar; but, as I cannot altogether confine myself to them, and must occasionally go further afield to languages more or less akin, let me just remind you of the great and completely accomplished feat of the modern science of comparative philology, the establishment of the unity of the Indo-European, Indo-Germanic, or, as they are now more commonly styled, the Aryan languages. Stated as briefly as possible, this means that the Sanscrit, the ancient language of India; the Zend, that of Persia; Greek and Latin; the Slavonian of Russia and Eastern Europe; the High German of Central Europe; the Low-German spoken along the southern shores of the Baltic, in Holland and in England; the Scandinavian of Denmark and Norway, and Sweden and Iceland; and, finally, the Gaelic of Ireland and Scotland with the Welsh of Brittany and Wales, are all but varieties of one tongue originally the same, varying from one another by certain fixed laws, but possessing in common a large stock of phonetic types, or primitive words, and a grammar in all its essential points identical. You will observe that I have omitted from my list such languages as French, Spanish, and Italian, not because they do not belong to the same family, but because they are all a step further removed. All the languages first enumerated, might be styled daughters of one common parent, the Aryan spoken probably about 3000 years before Christ; while the French, and the other so-called Romance languages, are daughters of one of these—the Latin. Of course, the farther back we can go in the history of those languages which I have classified together as Aryan, the more shall we rid ourselves of those changes which time, and the likes or dislikes for particular sounds on the part of the nations using them, have wrought, and we shall see more plainly the simpler laws of divergence from the original type—laws the origin of which is lost in mystery, but the operation of which must have as effectually divided the different Aryan tribes from one another, as the confusion of tongues divided the Babel builders on the plains of Shinar.

I shall take for illustration in its bearing on the original roots of the Aryan languages one of the best known of these laws, one of the widest application, and trace it through a few examples. It is called Grimm's law, after the great German philologist, who died only a few years ago, who was the first to enounce and establish it.

Your ear will tell you at once that *pa*, *ba*, *fa*, that *ta*, *da*, *tha*, are similarly related, and that *ka*, *ga*, *cha*, are also kindred in the same fashion. The hard aspirate *cha* (though it is still common in German and in Scotch) we have lost in English, and substitute for it usually the simple aspirate *h*. You will also easily understand why the sounds of *pa, ba, fa*, should be called labials, because pronounced entirely by the lips—in Latin *labiæ*; *ta, da, tha*, dentals, because their sounds are formed by more or less complete contact of the tongue and teeth; and *ka, ga, cha*, gutturals, because they are sounded by the compression of the throat, which in Latin bears the name of *guttur*. And you will, on examining the nature of the sounds, easily comprehend why *pa, ta, ka* (the first of the series in each case) should be called tenues, or thin letters; first, because for sounding them the passage of the breath must be for the briefest possible portion of time wholly arrested, and secondly, because their sound is short and sharp. You may repeat it, you cannot dwell upon it as you can upon other consonant sounds, for instance, the three in each series *fa, tha, cha*—the so-called aspirates, or breathed letters, because in uttering them the emission of the breath is continuous, and the sound, therefore, capable of indefinite prolongation. Intermediate between the two—not so hard as the tenues, not soft and flowing like the aspirates—come the sounds of *ba, da, ga*, called, therefore, medials, as possessing no special peculiarity of utterance, but lying between the two extremes of tenues and spirants.

Now, Grimm's law stated concisely is this:—Where you find a tenuis, *pa, ta, ka*, in Sanscrit, Greek, and Latin, you shall find in German a medial, *ba, da, ga*, and in Gothic, the oldest known type of English, and in English generally, an aspirate, *fa, tha, cha*; and similarly, by what a mathematician would call substitution, if the first group give you a medial, German shall give you an aspirate, English a tenuis; and if the first group give you an aspirate, German shall present a tenuis, English a medial. It would be impossible for me to enter fully into the exemplification and establishment of this law, but I may venture as briefly as possible to put before you some of the commoner familiar words, in which we find its operation beyond a doubt.

Begin with some simple indispensable words—say the definite article or demonstrative *the* in English, with its derivatives, *this* and *that, then* and *there*. What answer to these in German and in Latin? In German a host of words commencing with *d*—to *the*, the feminine *die;* to *then, dann;* to *this, dies;* to *that, das*. Notice this last form particularly. Our English sound of *th-*, which according to the law should in German replace an English *t*, is to a German's organs of speech nearly unpronounceable, I presume because unpleasant; and *s* or *z* or even *tz* does duty for it. This you may have observed when in the earlier part of my remarks I quoted the English *sit*, the Latin *sedes*, and the German *sitz* as identical words. And what do you find in Latin for our English *th-* demonstratives? Just what the law bids us expect—a series of words beginning with *t*—*tot*, *tam*, *tum*, *talis*, and the like.

Take another word, the second singular pronoun so nearly obsolete in our daily speech, *thou*. Everybody knows its corresponding forms—the German *du*, the Latin *tu*. And so again, the English *three* recurs in German as *drei*, in Latin as *tri*, familiar to us as a prefix in such words as *triple*—the exact equivalent in meaning and in letters of our English threefold; for Latin *p* should by analogy be English *f*. And what cognate forms do you find for our numeral *two*, where the *w*, though not now sounded, must once have been pronounced as it still is in *twilight*—the light *between* day and night? In German, for the initial tenuis *t*, the law bids us look for the aspirate, *th;* in Latin for the medial *d;* and what do we find? In German, *zwei*—*z* replacing the impracticable *th;* in Latin, *duo*, well known to us all in *dual*, *duel*, or *duet;* and in the verb, *doubt*, which we have borrowed from Latin. For what means *doubting*, *dubitating*, to which corresponds in meaning and in etymology the German *zweifeln?* Merely this, not to know which of two ways to take—or, as we say in humble phrase, to be in two minds.

Before quitting these exemplifications of the law from dental letters, there is one root or type to which I should like for a moment to call your attention, which in Latin appears as *ter*, signifying to rub or to wear, the participle of which has become an English word, as when we speak of a trite saying, meaning one well worn and familiar—rubbed, as coin is in its passage from hand to hand. This root is interesting to us, as showing how gradually the meanings of words change. What is the effect of rubbing, if continued? why, a hole! And hence this root has taken in Greek almost universally the sense of piercing instead of that of rubbing, whence we have the name of the boring-worm, so destructive to wooden piles in Australian seas—the teredo or the piercer. Nor is this unknown in Latin, for there we find the word *ter-ebrum*, a gimlet, a boring instrument. Similarly the root claims acquaintance with us in German, as the preposition *durch*, own cousin and representative of our English *through*; or again as the German *dorn*, the English *thorn*—the piercer. Nor have we yet ended with it among our homely words; from it come directly the verb to thrust, found in its true sense in the New Testament words, "shall be stoned or *thrust* through with a dart;" and the noun, a "thrill"—a sudden feeling—piercing as it were through the heart. Indeed, as Archbishop Trench pointed out long ago in his admirable *Study of Words*, this very word occurs daily to us in its original signification of a *hole*. For what is *nostril* in olden English? Why, *nose thrill*—the passage pierced in the *nose*, where, by virtue of another phonetic law, which we shall presently recognize, the aspirate sound of *th-* has been changed to *t* by the contact of the sharp *s*.

At the risk of *boring* you with this root *ter*, I must ask you to follow its development one step further. Set to work to rub, and see what form of motion your hand will almost certainly assume—a rotary one, and hence it is that in Greek and in Latin the root finds another expansion into τρεπω, or *torqueo*, to turn or twist. From the former of this we have the well-known word *tropics*—the places where the sun seems to pause and turn back in his gradual daily northing or southing, as the case may be. From the latter we have the Latin *torqueo;* the Irish *torque*, the twisted collar of gold; and the *torch*—the twisted rope which, smeared with pitch, served to light in olden days; the *retort*, whether it be the argument which, flung at you, you twist back against your antagonist, or the twisted, bent alembic that the chemist uses; and finally the tortuous course of a river like our Yarra.

Leaving the dentals, let us look for an example or two of our canon among the simple roots involving labials. First meets us the English *off*, the German *ab*, what should be its Greek or Latin analogue? *Ap*—but *ap* it is not in Greek or Latin, for here we come across a law of euphony common to the two tongues. No word in either language terminates in *p*. Therefore, in Greek, the objectionable final sound is disguised by the addition of a light vowel, and the word becomes ἀπο, familiar to us in *apostrophe*, *apology*, and many another adopted alien; while in Latin, the *p* is softened down to the gentler *b*, and the result is *ab*, well known to us in *abuse*, *abhor*, and numerous other borrowings from the tongue of ancient Rome. Or again, *pro* is our English *fore*, *primus* almost exactly our *former; pleo* is the Latin for I *fill*—give but the English of the word, and you see the law fulfilled at once; and as secondary forms of this root, with the notion of number or multitude, we have the Latin *plebs* (the common people), the German *volk*, and our own *folk*, in which the *l*, though unpronounced, bears silent witness to the origin and meaning of the word. Another wide-spread root is *pa*, meaning in Greek and Latin to *feed*, and familiar to us in its derivatives *pastor* and *pasture*, the feeder and the feeding-ground. Does no more familiar word, however, arise at once to our thoughts as connected therewith? Surely yes, the Latin *pater*, our English father; no other etymology can be assigned to either—the father is the feeder, he who is bound to give food to those who owe their being to him. Another derivative from it in Latin is *pecus*, cattle, literally the feeding or grazing thing, whereto corresponds letter for letter the old English word *feoh*, cattle, now obsolete and surviving only in the name of the *fee* paid to the barrister; strange testimony to that older state of society, when payments were made, not in money, but kind.

Before leaving this great law of letter change, I may, perhaps, without wishing to multiply instances, merely indicate one or two more examples of its operation. The English verb *to bear*, corresponds in meaning and root to the Latin *fero*, seen in our *prefer*, *confer*, or *infer;* our *heart* corresponds to the *cor*, which we know in *cordial*, the synonym of hearty; *kin* to the Latin *genus*, in which we usually soften the initial letter, genus, and whence we derive general and generic, of or belonging to a class or kind; and, finally, our thunder exactly reproduces the German *donner*, and the Latin *tonitru*.

I will ask you now to consider a few roots or phonetic types in which the letters are such as not to be subject to the law of change above quoted and exemplified, or in which some cross law has prevented its operating.

To begin with, suppose I ask you why a shoe was called a shoe?—something to do with the foot, I imagine, would be your not unnatural reply. And I fancy you will smile when I aver to you that the word is of the same etymology and all but identical in meaning with the name of the heaven that bends above us—the sky. And yet a little consideration may make this plain. First, a shoe does not necessarily mean aught connected with the foot, for in German *handschuh* is to this day, a glove; a hand what? hand-covering, one would naturally reply. Now according to a universal law of word evolution in modern English, *shoe* represents an old form *scô*. Turn up your so-called Anglo-Saxon dictionary, the dictionary that gives you the English that Alfred spoke and wrote, and there you will find the form I have just given you, *scô.* Now you see both form of word and supposed meaning are tending to reconcile our seeming widely-parted *shoe* and *sky.* But you shall have a little more evidence. The root *sku* must have meant originally to cover or to hide; for take its obvious derivatives and examine them. Σκῦτος is the Greek for *skin* (you see there can be no letter change of the κ by reason of the sharp preceding *s*), and what is that but our body covering? Σκια is your English shade, or older *scadu,* and what is that but a screen from the blazing rays or a covert from the sun? *Scild* is the primitive of your modern shield, and what is that but a protection from the sword or the arrow? And what, finally, is the sky but *the* great covering spread over His earth by the Almighty, who covereth Himself with light as with a garment, who stretcheth out the heavens like a curtain? May I claim to have proved my case, and shown how the imagination of man, seeing likenesses in things apparently dissimilar, has given names of like import to the poor buskin that we trample under foot, and to the blue dome of air that arches illimitably over-head?

I must content myself with shortly noticing two common roots in which the letters not coming under Grimm's law remain alike in all the Aryan languages. The first shall be the pronoun *me.* This one word, identical in all, and of such a kind that we cannot imagine its being borrowed from one section by another, would, if it stood alone, go far to prove the original unity of the Aryan family. And the second shall be the root *man,* to think, found in Greek in μενος, usually signifying might, for *thought* is *might.* In Latin, *mens, mentis,* whence our adjective mental; in *memini,* I have called to mind, whence our *reminiscence;* next in our substantive *mind;* and last, not least, in the title we give to ourselves, "*man,*" the thinker. A noble name is this, to which all the Germanic peoples have cloven as the appellation of their race, a name that bids us look up to Him who gave us thought and being—far nobler than the Latin *homo,* which, if the usually accepted derivation be correct, bids us look down to the *humus,* the dust of the earth out of which we *were* made, but to which we shall not wholly return.

And now for a brief glance upon the synthetic stage of language in which, out of type forms, modified words took their rise, in which inflections and all we commonly call the accidence of language began. Think what an enormous step was taken when first it entered into the mind of man to express plurality, more-than-one-ness, by some termination to be appended to *all substantives* alike, in place of prefixing some vague numeral like *many*. It does not matter if the termination so appended was originally a fragment of an independent word; the great stride was in reducing it to a symbol. Or, again, consider how all the precision of thought was assisted by the terminations of cases such as we find them in Latin, Greek, or Sanscrit. Try and imagine a state of language in which such a combination of words as *man house is* might have left you doubtful whether the meaning was, the house is belonging to the man, the house is for the man, the man's house exists, the man is in the house. All these varieties, save the third, we now distinguish by prepositions, our substitute for cases; but Greek could effect them all by the use of its cases. Again, reflect what a device for conciseness was that which all the older Aryan languages present to us, the appending of pronouns in the nominative cases at the end of the verb. Think what a relief it would be to me, or any other person addressing an audience, if, instead of the capital *I*, which it has been so often necessary for me to employ, my personality could have disguised itself under a harmless long *ō* at the end of all my verbs, as in Latin and in Greek.

But the inventive faculty of man seems to me even more strongly evidenced in derivation, than in inflection. For you can dispense with inflections, or at all events we have dispensed with most that have been current, have tried them and found them unnecessary; or, more correctly, have found that some not too awkward periphrases might replace them. There is no doubt that our language has thus lost both in gravity and in terseness. You cannot adequately render a good piece of Greek or of Latin, without employing more words than you find in the original; and in spite of the abundance of our monosyllabic words, I doubt if you could do it in as few words, or as few letters. But the fact remains, we can do and are doing without many inflections once current; we have dispensed with scarce any modes of derivation; on the contrary, in addition to our own native forms, we have borrowed many from Latin and from Greek.

We saw earlier that, in all probability, verbs, nouns, and adjectives were alike portions of the most primeval speech. By the process of derivation, I mean the systematic formation of one or other of these classes from any one before existing. The Latin *facio*, *factor*; the English *do*, *doer*, will at once make this plain. Here the starting-point is a verb, and a symbol is invented, which may be put on to any verb whatever, and shall make out of it a name for the man who does the action which that verb names. Or, again, consider *verus, veritas; true, truth.* Here you have another symbol, which marks not merely an advance in expression, but a vast onward step in *thought.* For the adjective was but the name of an object; here you have a name of something you cannot see at all, but which you have in your thought created, and imagined as existing in the object to which you heretofore applied the adjective. We shall not, therefore, be surprised to discover, what the history of language and its formation teaches us, that few, if any, of *abstract names of qualities* are *original roots,* or phonetic types, to revert to Professor Müller's word. They are constantly based upon either nouns or adjectives, or even upon verbs, by the addition of some termination which usually is a modification of the third personal pronoun, the demonstrative *t* in Latin, *th* in English, giving that-ness or outward existence to this, our mind's creation. But you must not imagine that derivation is confined to the addition of one such termination to a primitive root; the superposition of such terminations may go on as long as the mind finds it not inconvenient to think up to the complex notion so formed. Let us take a sample or two at random. Our English *truthfulness.* Well, here we start with an adjective *true,* meaning literally hard or firm, cognate with the Latin *durus,* hard, the Greek δρῦς, and the English *tree.* Append to this *th,* and you have the name of a quality, truth. Compound the adjective *full,* and you revert to a name applicable to a person filled with the quality *truth.* Now add the symbol *ness,* and you construct again an abstract noun, signifying, originally, the outward semblance, but it may be also the very inward state or quality of the truthful man. Or take a Latin example—*impecuniosus,* our English *impecunious.* Here we start with our old friend, *pecus,* cattle; thence we advance to *pecunia,* the state of possessing cattle, or, briefly, *wealth;* then onward to *pecuniosus,* full of the state of cattle owning, or wealthy; and, finally, we negative this, namely, prefixing *im,* the symbol of negation, and make our name into not-wealthy or poor. I must have one Greek example for you, for the sake of the singular change the word has undergone. You all know what an *alms* is; possibly you do not know the history of the word. To commence, there is a Greek word, ἔλεος, meaning pity. Thence was formed a verb, ἐλεέω, I pity; thence an adjective, ἐλεήμων, pitiful; and thence, finally, ἐλεημοσύνη, pitifulness. But, forasmuch as pitifulness is not pitifulness unless manifested in act, this word easily passed into the signification of money given for the poor; and in this sense was adopted by the early Christian Church. Thus become the name of a duty, it spread with the spread of Christianity, and was carried with it far and wide. In point of fact it exists in our English of to-day, with a Latin termination tacked on to it, in the hideous word *eleemosynary*, which we do occasionally see. However, as each nation adopted it, they knocked the cumbrous word into shape to their own liking; the German made it *almosen*, the Frenchman *aumone*, softening out both *l* and *s*, and our English forefathers abbreviated it to *œlmesse*, which Scotland has yet further cut down to an *awmous*, England to *alms*.

Modern English, in this matter of forming new words by derivation, is very potent. We have not only retained most of our own formative terminations, but we have drawn largely on Latin, two have been just used, *ive* and *ation*; and even upon Greek, as when the other day, with true recklessness about hybridism or the mixing of words and forms coming from different languages, we, desiring a new name for a new act, took the quasi-Greek word *climate*, stuck in front of it the Latin *ad*, and at the end of it the Greek *ἴζω*, and developed the verb acclimatize. Not a bad or a useless word, for see how very complex an idea it conveys. How shall we phrase it? To adapt to a given climate natural productions which were not previously found in it. Will that do? Nearly, I think, but, considering the length of this, we ought to be much obliged to the man who invented one word to express it all. But not content with his good work we must append, further, the pure English *er*, in the place of the legitimate Greek *ist*, to denote the doer; and then, by way of variety, select the Latin termination *ation*, for the name of the deed when done.

It remains that I should say a few words on the wear to which words are subjected in their passage down the stream of time, such as may have been observed in our puny *alms*, small relic of the rolling Greek ἐλεημοσύνη. Changes in the form of words are usually traceable to one or other of three causes;—1. The inability of some people to utter a particular sound. 2. Their dislike to some particular collocation of sounds, or generally a love for euphony. 3. A desire for contraction, or, what is much the same, more rapid enunciation. Perhaps all the three might be reduced to one—laziness; for as to the first cause, it is certain that there are very few sounds in any language which you could not teach every child to pronounce; as to the second, our idea of euphony is little beyond that which is easily said, and therefore we like to say; and the third is undoubtedly laziness, pure and simple. But the three will at all events serve as a basis for classification. As regards inability to utter particular sounds, we English folk suffer very little from that. Among all the Aryan languages, the Sanscrit is in its system of sounds the fullest, and next to it I should be disposed to place our own. Of almost all the modern nations of Europe we alone can utter distinctly both *v* and *w*, can distinguish between *vine* and *wine*, and we alone have the complete system of palatal sounds. One important sound however we lack, the χ, the guttural aspirate. From the dislike to this, which has developed into inability to utter it, has resulted that great standing anomaly, the varying pronunciation of the terminal *gh* which gives foreigners such annoyance. But a Latin could as little articulate χ as an ordinary Englishman; and besides this he could not utter θ at all. And so our good English verb *to greet* looks as if it were derived from the Latin *gratus*, acceptable. It is the same word, but not because of its similarity, but in spite of it. For the root in Latin ought to have commenced with χ as it does in Greek, as we know from the word Eucharist; but failing the χ, the Romans used their nearest sound, the hard *g*. Again, you might have expected the English *deer* to have found its equivalent in Latin, as it does in Greek, in a word commencing with *th*. But given *th* impossible, what were the Romans to do? Much what we did in the case of *enough*, *draught*, and other such words; they took the nearest aspirate, *f*, and accordingly the Latin analogue to our *deer* is *feræ, untamed creatures* generally, whence, ultimately, our *fierce* and *ferocious*.

The dislike to particular combinations of sounds is very strongly marked in all nations, but is peculiarly dissimilar. For instance, if in Greek a dental sound and a guttural came together, they must be made precisely alike in character. The familiar English word *practice*, which is Greek in origin, will illustrate what I mean. The *k* sound which precedes the *t* ought to have been a hard *g*, but was modified to suit the following tenuis. But our English forefathers had a positive hatred of two aspirants coming together, a collocation of sounds in which a Greek's ear would have delighted, and hence you will discover in English anomalies in the formation of derivatives. For instance, *long* gives *length*, and *strong*, *strength*, but *high* gives not *heighth* but *height*. So *till* gives you *tilth*, but from *give* is derived *gift*, from *thieve*, *theft*, and the *k* of *think* and the old *y* of *may* were changed in the derived substantives into *gh*, the aspirate in *thought* and *might*.

To the third cause, however, the great change in the forms of words is mainly due in our own as in other tongues, and it has taken effect mainly in the gutturals, which are after all the hardest and most troublesome letters to sound. What has become of the *k* and the *g* which are still written in *know*, *knee*, *gnome*, *apophthegm*, and *phlegm?* What of the *h* which once preceded *ring* and *raw*, the loss in the latter word concealing its identity with the Latin *crudus*, our *crude?* I pointed out to you, in the instance of the word *shoe*, that nearly all our words commencing with *sh*, *shall*, *share*, *shape*, *shell*, and many more, had all once an initial *sk*. Try the difference in time between saying *skip* and *ship*, and you will recognise at once the cause of the change. Similarly, nearly all our words now commencing with *ch* originally began with a *k* sound, and this whether English pure or Latin adopted through French; *churl* is the old English *ceorl* as surely as *charm* is the Latin *carmen*. Nor is it at the beginning only of words that the gutturals have suffered this maltreatment; they have fared as ill at the end. All our adjectives that end in *y* once ended in *ig;* our adverbial termination *ly* was once *like* at full length; *hedge* was once *hage; edge* once *eg*, as you see it in the name *Egbert*, the bright *edge*, or in the verb to *egg* a man on, to whet or sharpen him. Nor are the gutturals the only class of letters which our desire for speed has crushed. No one now says *nătĭōn*, but *nāshōn;* and some years ago it appeared as if *picture* and *nature* were to become in English *piktcher* and *nacher*. The great spread of education, and the fixing thereby of our standard of speech, has done much to arrest this tendency in our language, and probably we may now consider the pronunciation of English as approximately fixed and permanent.

My task is done, I know too well how imperfectly, and I much regret the haste with which I have been driven to pen my few remarks. My object is attained if I have excited in any of my hearers some desire to give heed to language, not alone for what it conveys to us, but for the thing it is in itself; and to note how the purpose of man has, half unconsciously it may be, yet still intelligently, been shaping this wondrous gift of God to him. Language is but words, words are but human breath; and yet the language and the words live on independent of those who first gave them being, and those in whose mouths they live again from century to century. Well for us if we remember that not only the language of a nation thus has life, but that to the words of each of us is given the like abiding permanence; for one day out of our words shall we be justified, or out of our words condemned.

THE OBJECTS OF A BOTANIC GARDEN IN RELATION TO INDUSTRIES.

A LECTURE,

DELIVERED BY BARON FERD. VON MUELLER,
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On 23rd NOVEMBER, 1871.

"Avoid extremes."

It was originally my intention to limit the lecture, promised for this evening, to an explanation of the bearings of botanic gardens to industrial pursuits; but I found occasion to overstep these precincts, to bring the many other objects of a true botanic garden also, at least briefly, under the view of this audience. The ideas of most people in reference to the meaning and duties of institutions of this kind seem so vague and imperfect, that it may be advisable to trace the early origin of such gardens, and to see likewise how far their legitimate functions are generally recognised at the present day; furthermore how far, as institutions framed for distinct purposes, they are able to exercise a vivid and powerful influence on education, on technology, on rural pursuits, and on the advancement of independent researches for the enlargement of phytologic knowledge.

The original and ancient appellation of "botanic garden" is hardly any longer applicable in the strict sense of the word, implying a garden for medicinal or otherwise useful herbs,

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NOTE.—*The Lecture was illustrated by a large number of growing Plants of industrial value, also by numerous Products and Educts derived therefrom, as well as by various Museum Plants, Physiognomic Pictures of Vegetation and other Drawings.*

inasmuch as the scope of establishments so named has become vastly extended; moreover, many of the numerous local gardens passing under this name, particularly in these colonies, have no claims whatever to such a designation.

If much inconvenience was not involved by the alteration of the term, it would be recommendable to recognise the true botanic gardens of this age as scientific gardens; while all those institutions, in which no real phytologic researches are carried out, or in which the main aim does not consist in affording instruction, might well be called public pleasure gardens, or perhaps recreation grounds or parks, according to the design for which they are created, or in consonance with the requirements for which they are maintained.

Let us now see how botanic gardens first originated.

The study of plants in Europe arose with the glorious genius of ancient Greece, the earliest historic records in Sanskrit, or the ancient discoveries of the Chinese, being yet wrapped in almost complete obscurity, particularly as far as plants are concerned. The Greeks and Romans sought chiefly knowledge of plants, which were available for medicine, rural economy, or the work of their artisans; the number of such plants in those dawning days of knowledge, while the range of commerce was yet so restricted, being necessarily quite limited. Hippocrates was acquainted with 236 different plants in use at his time (460–351 B.C.). Tyrtamus Eresos, or Theophrastos, as this favourite disciple of Plato and Aristoteles is usually called, records 455 in his writings, some not indigenous to Greece (370–288 B.C.); his knowledge being largely imbibed from the teachings of his masters, who must be regarded as the founders of botany as a science, just as many other branches of knowledge owe their origin to these great philosophers. Diogenes Laertios informs us, that Theophrastos and his pupil Demetrius Phalerius, who for ten years was Regent of Athens, possessed a garden, containing as well exotic as indigenous plants, in which he assembled his disciples. This has been considered by some, Cuvier among others, as the first attempt at a botanic garden, and doubtless it was here that Theophrastos instituted many of his numerous observations. Only with the renewed brighter dawning of knowledge in Western Europe, his works became there accessible in the fifteenth century, when a Greek refugee, Theodore Gaza, was induced by Pope Nicholas V. to translate into Latin various of the writings of Aristoteles, the *Aphorisms* of Hippocrates, and also Theophrastos' *Natural History of*

Plants. Gaza died in Rome in 1478, and the translation appeared first at Trevisa in 1483. The work contains notes on the structure, habits, properties and modes of propagation of plants, and enumerates, to a certain extent, the species considered utilitarian at that remote time. Many of these results must have been obtained in Theophrastos' garden. Two other disciples of Aristoteles, Phamias Eresios and Dikaarchos of Messene, and a third, whose name remained unknown, have handed over to us by their writings the views entertained by their teacher and themselves on the nature and properties of plants, as recognised in those distant days; but we have no record of their possessing special scientific gardens.

From the time when the political preponderance of Athens was sinking, dates also the decay of learning, once eminent among her citizens. Instead of Athens, for a considerable time Alexandria became the seat of sciences and arts, carried thither principally by Greek emigrants; and mental culture flourished there under the protection of the Ptolemaian Kings of Egypt, amidst the horrors and cruelties of that age. Under the wise reign of Ptolemæus Philadelphus (285–247 before Christ) the Museum and Library were founded, the latter then already containing 400,000 rolls. But although Alexandria shone like a sun in the constellation of lesser stars in regard to learning and civilisation, yet wherever Hellenes became scattered they carried with them their love of science; and it was especially the flourishing town of Pergamos, on the Black Sea, which distinguished itself by scientific eminence in that early period. Besides an extensive library, King Attalus Philometer (died 133 years before Christ) established a garden for poison plants and their antidotes, and for the same purpose a garden was formed during the reign of Mithridates Eupater, of Pontus (136–63 years before Christ), while the patronage of these sovereigns was enjoyed by the two most celebrated rhizotomists of that time, Kratenas and the physician and linguist Nikander of Colophon.

Dioskorides, at the beginning of the Christian era, extended much these early researches, more particularly in regard to medicinal plants; and his work and that of Plinius continued for nearly seventeen centuries the codex of medico-botanic science, it being rich in observations gathered by the former while surgeon to the Roman legions, and it is consulted yet as an authority in the Orient. Dioskorides' work, as well as the writings of Aristoteles and Theophrastos, contributed much to the *Historia Naturalis* of the elder Plinius, who was so famed as an admiral, statesman and philosopher (23–79 A.D.). Plinius mentions that Antonius Castor, under King Dejotorus of Armenia, possessed a botanic garden at the time of Julius Cæsar.

From the famed surgeon Galenus of Pergamus, who much recommended the study of native medicinal plants, we have to pass through a long interval of comparative scientific darkness, in which phytology particularly shared. Useful plants were, however, in many instances cultivated by the monks. The medical knowledge of the Arabs was carried through the crusades to the Occident, and thereby new information of many plants was secured. The Benedictines, in 1309, formed, with the medical school of Salerno, also a medical garden. In 1333, the botanic garden of Venice was established as an institution accessible to the public. Lucas Ghini formed successively the botanic gardens of Padua and Pisa in the first half of the sixteenth century. About that time also such institutions were organised at the Universities of Bologna and Pavia. Duke Alfons of Este formed one at Ferrara. Belleval was instrumental in the formation of the botanic garden at Montpellier, early in the seventeenth century. All these South European institutions are still in existence, and with most of them the one of our young colony continues in communication.

The elder Camerarius, in 1588, described his private garden of Nürnberg (Nuremberg) as "*hortus medicus et philosophicus.*" The University of Leyden provided its garden in 1577; that of Paris dates from 1633. Queen Elizabeth created the first in England, at Hampton Court, of which Parkinson was the administrator. Bobardt was the first director of the Oxford garden, in 1632. The Bishop of Eichstedt formed one at St. Wilibald, under Besler, which gave rise to a descriptive work in 1613.

Peter the Great, amidst his enormously active exertions to regenerate his colossal empire, could still find time to create, in 1714, at his new capital, the great botanic garden, which stands now amongst the foremost of all, notwithstanding the inclemency of an inhospitable climate. The Emperor, not unaccustomed to take counsels with philosophers, planned this garden on the advice of Leibnitz. The botanic garden of Edinburgh was already founded 200 years ago. Henry Nicholson gives an account of the plants of the Dublin medical garden in 1712.

But why do I enter on these historical details, many of which are almost buried in oblivion? I did this, because I wished to demonstrate, that from the early transcendental days of Greece up to the most recent decennia all institutions designated as botanic gardens were mainly or exclusively devoted to the rearing of such plants as were adopted for medicine, for alimentary or industrial purposes; and it would be little short of relapsing into barbarism, were we to alienate any such institutions of ours entirely from their legitimate purpose.

By way of illustration let me offer a few words on recent eminent institutions of this kind. As one of the most important of all botanic gardens of the European continent, may be instanced that of Breslau, founded in 1811, and since 1852 under the direction of my venerable friend, Professor Goeppert, who conducts his administration in accordance with the highest principles of science. I am not aware of the precise present contents of that rich establishment, but already in 1857 it possessed about 3000 annuals, 4000 hardy* perennial herbaceous plants, about 2000 species and varieties of unprotected shrubs and trees, and about 3000 different kinds of plants under glass. This garden is remarkable for its physiognomic groups, of which there are 84, and to augment these the tropical plants are placed from May till September in the open air. Unique in the Breslau establishment is the display of fossil plants, restored from original specimens, to exhibit them not merely fragmentary, but as much as possible in their pristine completeness. Carpologic collections are made from the living plants with the most circumspect and scrupulous care. The botanic garden of Munich was founded in 1809, at a time when the horrors of apparently endless wars concussed the whole of Europe; it was long under the surveillance of the deeply-learned philosopher and celebrated Brazilian explorer, Von Martius, whose memory must be dear to every one who was brought in communication with that great man. This garden contained in 1851, in its conservatories alone, about 5000 species of tender plants.

If necessary, I might enter on long expositions concerning the workings and contents of the principal botanic gardens of former times or the present days; but I will rather at once define the conclusions, to which all these statistics or other comparisons would lead us, only yet premising, that among all existing state gardens none can be compared to the grand and justly-famed establishment of Kew. While the highest scientific administration is there brought to bear, it is also seconded by the enlightened and commensurate support and the princely endowments of a great nation.

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* The latitude is that of London, but the climate is much colder.

The objects of a botanic garden must necessarily be multifarious, nor need they be, in all instances, precisely the same; they may be essentially modified by particular circumstances and local requirements, yet, in all cases, the objects must be mainly scientific and predominently instructive. As an universal rule, it is primarily the aim of such an institution to bring together with its available means the greatest possible number of select plants from all the different parts of the globe; and this is done to utilise them for easy public inspection, to arrange them in their impressive living forms, for systematic, geographic, medical, technical or economic information, and to render them extensively accessible for original observations and careful records. By these means, not only the knowledge of plants in all its branches is to be advanced through local independent researches, conducted in a real spirit of science, but also phytologic instruction is to be diffused to the widest extent; while simultaneously, by the introduction of novel utilitarian species, local industries are to be extended, or new resources to be originated; and, further, it is an aim to excite thereby a due interest in the general study and ample utilisation of any living forms of vegetation, or of important substances derived therefrom.

All other objects are secondary, or the institution ceases to be a real garden of science. But the detail interpretation of these fundamental rules may be more or less rigorous, as the extent of the operations thus designed must very largely depend on the natural facilities and monetary means which are at command for the purpose. Moreover, the early attainment of any of these varied objects must evidently be all the more difficult in a new country, where in the first generation we are passing yet through the laborious and expensive process of founding all those institutions, from which in the natural course of events a later time can only derive the fullest benefit. But in all these planting operations indicated for scientific demonstration we can still find full scope for the display of tasteful ornamentation and picturesque grandeur.

A real botanic garden, then, ought to display the living vegetation in its multifarious forms as far as ever local circumstances will permit. All the plants of the globe build up together a great harmonious system in nature; they are all referable to distinct specific forms, all created by design of an Almighty power for special purposes; they are, moreover, all endowed with well-defined qualities, all interesting and beautiful in themselves, and eligible for our varied wants. We may accumulate collections still more extensive for our phytologic museums than for our garden displays; but we still need to study, as far as we can, the forms of the vegetable empire in their living freshness, their natural grace and vital beauty. What can be more instructive than to compare allied species, from often widely distant parts of the globe, when placed in culture side by side? Or, what can be more impressive than to watch how in succession the specifically ever-unalterable forms unfold themselves before our view or sink again into rest? To accomplish great results in all these respects we have in our climatic zone enviable facilities; and thus horticultural pursuits for strictly scientific purposes become also here far more grateful than in the countries of colder climates where most of us spent our youth. Remember only how, irrespective of the plants of colder latitudes, we can have under the open sky around us the plants of all the Mediterranean countries, Arabia, Persia, the warmer Himalayan regions, China and Japan; how we can rear here without protection the marvellously rich and varied vegetation of South Africa; how in our isothermal zone we can bring together the plants of California, New Mexico, Florida and other southern states of the American union; and how we need no conservatories for most of the plants of Chili, the Argentine State and South Brazil. In Australia we require hardly to allude to the singularly peculiar vegetation of New Zealand, or the gay, curious and remarkably varied vegetation of West Australia, because we are rightly accustomed to regard these neighbouring colonies as portions of the great integral southern empire of Britain; but it requires to have studied the vegetation of Australia and New Zealand specially to appreciate its richness, and to understand fully its value for a garden in a colony like Victoria.

Thus, for geographic and for systematic culture, both primary objects of a botanic garden, singular facilities arise to us here, and this I cannot better demonstrate than by some exemplification. South Africa possesses, for instance (according to Mr. Bentham's elaboration, issued by the elder De Candolle in 1839), about 400 real Ericas, many so long the charm of European greenhouses, and there are about 100 more of Cape Heaths, though not true Ericas. Collateral to the Cape

Heaths, and not less handsome, are our own Epacrideæ, with about 200 Styphelias and generically allied bushes, and again 70 capsular species of Epacris or cognate genera. Professor Harvey and Dr. Sonder, in their great work on South African plants, describe about 50 Muraltias, 70 Hermannias, over 100 species of Oxalis, about 150 species of Aspalathus and at least 150 Everlastings; among the latter alone 137 veritable Helichrysums. The Australian Immortelles, largely from the West Coast, are in some instances still more lovely. They amount to more than 100, among them about 50 Helichrysums and 30 Helipterums. This calculation leaves Everlastings of other orders, such as Ptilotus, Laxmannia, Calectasia, &c., uncounted. Of all these, as yet comparatively very few have found their way into our own gardens, although these plants would need here singularly little care. Still less horticultural attention is essential for the wonderful variety of succulents with which South Africa teems. You may have seen, spring after spring, or summer after summer, the gayness of at least a few species of Mesembryanthemum, unfolding under the sun of our clear sky a dazzling brilliancy of starry flowers, on which the eye is almost unable to rest. Of these Mesembryanthema nearly 300 species exist in South Africa, mere varieties uncounted. But the array of succulents does not end with them. There are also a quarter of a hundred of Cotyledons, no less than 100 Crassulas, more than 100 Stapelias, about 160 kinds of Aloe, several Kleinias, Cactus-like Euphorbias, and a good many others, all highly desirable for scientific garden collections, some quite paradoxical. Thus, South Africa alone gives us nearly a thousand succulents, many, I fear, under the progress of settlement doomed to absolute annihilation. When speaking of succulents, hardy here, I do not comprehend among them the generality of Cacteæ, of which it is assumed, that about a thousand kinds occur, all with one exception American, mostly however intra-tropical; yet also many of these do not demand protection under our sky.

I cannot extend these details much, but our means of communicating with the Cape of Good Hope are seemingly on the increase, and so our facilities of acquiring; more particularly since Her Majesty's representative will now also prove a dispenser of generosity from thence. I may, just in passing, remind you of the existence of sixty Phylicas, nearly as many Asters, Sphenogynes and Athanasias, and three times as many Senecios (the latter including the pretty S. elegans), none of all these coming amiss to a botanic garden. There are over 100 Indigoferas, many of them very handsome plants, in South Africa, none, I believe, ever subjected to the trial whether pigment can be obtained from them.* There are many Podalyrias and other leguminous bushes, which a horticulturist here may well covet, when we see how much the few species hitherto introduced already contribute to the spring-glory of our gardens, and how completely they are able to cope with the vicissitudes of our climate. As for bulbs, they also attain their maximum in South Africa; this a glance at the bulbous flowers of any garden will testify; but we know little yet of the Lilies and numerous other flowers of California and Texas, in a horticultural point of view—many modest, it is true. New trans-pacific communication has lately brought these with their floral companions also within our easy reach. The heath-like Diosmeæ of South Africa, all charming bushes, number (according to Dr. Sonder's disquisition) 170; Agathosma alone counts 97 species, of which hardly any yet are existing here. These pretty plants, which cannot sustain themselves out of doors in the inclement northern countries of Europe, we surely should like to grow here, along with our Australian diosmeous Rutaceæ, in gay array, for pleasing contrast, or systematic and geographic comparison. If we also add the superb Australian Diosmeæ (Boronia and Zieria 67, Eriostemon and allied genera 66), we obtain over 300 kinds of this admirable tribe of plants to select from.

The Proteaceæ of Australia and Africa might also be considered together, as they belong to the same climatic regions, and might here be reared alongside of each other. Professor Meissner admits nearly 250 South African Proteaceæ, among them about 60 Proteas, 50 Serrurias and 50 Leucodendrons, the latter including the Silvertree of the Cape. Undoubtedly this is a remarkable wealth of Proteaceæ, an order now only occurring in fossil forms in any part of Europe; but, through my aid, and in sequence of prior researches (chiefly of R. Brown and Meissner), it has latterly been shown by Bentham that Australia is still richer in these plants, as it can pride itself on no less than 576 Proteaceæ, among which Banksia and Dryandra united count 93 species, Petrophila and Isopogon together 64, Persoonia 59, Hakea 95, and the genus Grevillea, which is familiar to all of you, 156 species; 30

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* A search for dye in our native Indigofera gave negative results. We know, in all, about 250 Indigoferæ, none European.

Grevilleas having been added by my independent researches, instituted chiefly in the Melbourne Botanic Garden. Is it not of far greater instructiveness and importance, to secure as many of these mostly rare and local plants for a true botanic garden, than to spend the same amount of exertions and outlay on numerous varieties of ordinary florists' plants, which almost every private garden already possesses? Is it not far more worthy of the objects of a botanic garden, to gather for instance the 143 pretty Heath Myrtles, chiefly of West Australia, which in their simple beauty cannot be surpassed, than to strive incessantly to add hybrid flowers to those on our garden plots, or to acquire some probably unmeaning new varieties, however delightful to the eye, yet perhaps only slightly larger or tinged rather differently to those which we had before? Let us, according to our means, extend our patronage to all that is brilliant as a mere flower, but not to the exclusion of grander aims. Of the charming Darwinia we might secure 23, some most exquisite; of Verticordia 37, of Calycothrix 34, of Thryptomene and other Heath Myrtles 49. This brings me to the allied Baeckeas with 54 species, the splendid Calothamni and Beaufortias both together 45 species, Melaleuca and Callistemon 107 species, Leptospermum, Kunzea and allied genera with 57 species. Numerous of the Heath Myrtles found their first elucidation in the Botanic Garden of this city. But be it well understood, that I do not wish altogether to discard the gorgeous acquisitions, which we owe to patient horticultural skill, even in a botanic garden. Let me, as an instance of phytologic requirements in this respect, adduce the genus Pelargonium. Its hybrid forms are now uncountable, and I should be sorry to banish these gaudy plants; still 160 specifically distinguishable Pelargonia exist in South Africa, their main geographic area, and I should sadly regret if the pure original and at the same time attractive and lovely forms of the genus, from which the garden hybrids all gradually sprung, were to be entirely superseded in preference to the latter.

> "First follow nature, and your judgment frame
> By her just standard, which remains the same.
> Unerring nature is divinely bright,
> One clear, unchanged and universal light;
> Life, force and beauty must to all impart
> At once the source, the end, the test of art."—Pope.

But is it necessary to dwell on all this so long, when the bearings of botanic gardens on industrial pursuits are mainly to engage our attention for this hour? It is, because a great multitude of foreign plants, never yet introduced, or not yet generally recognised as valuable, might be made subservient to horticultural and other industries. A rich assemblage of rare plants becomes a great treasure in our climate simply by the yield of seeds; or by affording the means for multiplication by cuttings or otherwise, the yield to become thus readily available for horticultural trade here and abroad; while many of the handsome shrubs of our garden-grounds do not produce seeds in the conservatories of colder lands. I fancy, that a square mile or two of heath-ground, well selected, and within easy access of railroads, could in a climate like ours be converted into a place of the utmost attraction and instructiveness, by bringing together and naturalising on such a spot all the gems of the heath vegetation, which South Africa, our own continent, or the moorlands of the Andes, the Himalayas and other countries produce. But not only could such a spot be decorated with the utmost profusion of gaiety and loveliness,* but it might, as pointed out, become also a source of great pecuniary gain, merely by the annual gathering of seeds from such a mass of rarities. Instruction from a botanic garden assuredly paves the way for purposes like these.

Would it not be of great importance to our artisans to see the 130 species of Eucalyptus, as the principal timber trees of this continent, all represented in a state garden here? About 50 of these were rendered known to science by Melbourne researches. Imagine the glory of some of these trees, when —as in the instance of Eucalyptus miniata—they are loaded with trusses of orange-coloured blossoms; or when, as in the instance of Eucalyptus phœnicea, a tree of this genus produces crimson flowers vieing with the Ratas of New Zealand, but shows an infinitely easier growth.

We should promote the cognisance of the timber, not merely from museum specimens, but also as much as possible from the living trees. In a young country particularly, our energies should be concentrated on instilling information in this way. But a tree planted during the early days of settlement, if thoughtlessly sacrificed in a moment, or allowed to perish from inacquaintance with its nature or value, cannot be restored to its attained size, even if replanted, before the end of this century.

As yet we know but little of most Oaks, as far as technology is concerned. We should watch their growth in various geologic formations; we should note their adaptability to certain climatic regions. About half-a-hundred kinds have been brought together here by myself, but there are 300 kinds in different parts of the globe to select from. Quercus Lusitanica has shown itself here one of the most eligible for avenues, on account of its rapid growth, its protracted verdure and complete umbrageousness.* Our Eucalypts are as eagerly tested and watched elsewhere, as we ought to ascertain the effect of our clime on introduced timber trees. Our Blue Gum-tree will still grow from Toulon to Nice; at Cannes the tender branches are frozen. At Golf Juan the tree does not suffer. It comes within our observations in a scientific garden, why wood is more durable when produced on certain spots, as compared to that of other localities, and in a similar manner should be carried on undisturbed utilitarian research in manifold other directions. One single plant of a tree, once obtained, can become the progenitor of vast plantations. It is no exaggeration when I say, that from a single imported Asiatic Ash 15,000 young trees were obtained by me for Victoria, and that from a solitary Tamarix plant 20,000 bushes, now scattered through our colonial shrubberies, took their origin.

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* For instance, above 100 species of Sundews could be brought together there.

It should be ascertained, how many of the 160 true species of Willows and of their numerous hybrids are available for wickerwork; and we should learn, whether any of the American, the Himalayan or the Japan Osiers are in some respect superior to those in general use. We are aware that the Sal (Shorea robusta) is hardier than the Asian Teak (Tectonia grandis), the latter naturally not thriving beyond the tropic circle; but we are not aware, whether the Sal will live in any sheltered forest clearings of Victoria, and how far the Sisso (Dalbergia Sisso), which is hardier still, and which, according to Colonel A. Crawford, stretches to the 32° N. in the Punjaub, can be adopted as a forest tree for this colony. In solving such questions, a scientific garden may afford material aid. We should like to see how far Californian Red-wood trees (Sequoia gigantea), or New Zealand Totaras, may give us good timber, when merely grown from cuttings in the open air.

Test experiments, initiated from a botanic garden, might teach us whether the Silk Mulberry tree can be successfully reared in the Murray desert, to supplant the Mallee-scrub, or what other utilitarian plants, such as the Fig, various Coniferæ, Tanners' Wattles*, grasses, &c., we may gradually establish there.

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* A variety of this species yields the nut-galls of commerce.

Numerous Pines and other industrial trees have been secured for this country, not merely in a few specimens, but in large masses. The Nut Pine of Nepal is brought thus at last before you. The King Pine or Dye Pine of the Himalayas I raised by tens of thousands; but even if we had them by hundreds of thousands through our moister and higher ranges, it would not be too much. When even a bundle of firewood on some of our diggings costs already some shillings, the question of timber and fuel becomes also to us one of constantly increasing moment, and thus in a botanic garden we should also give to this grave question some practical and enlightened attention.

As regards deal wood, which naturally not occurs in our ranges, you will be cognisant that within the last few months more was consumed by the flames, raging through many of the forests of Canada and the United States, than would have sufficed to supply Australia for a generation.

Again, I cannot imagine anything more interesting than a full collection of Acacias, of which Australia alone furnishes (Albizzia and its sub-genus Pithecolobium included) 300 species, all hardy here. What delight is experienced, when as the first harbingers of spring the early wattle-flowers burst into bloom, converting bushes or trees almost into one mass of gold, and diffusing fragrance widely through the air. To me 300 Acacias appear far more valuable than 300 varieties of particular fancy flowers, at least in a young botanic garden, where their names, their native countries, and perhaps even the uses of many could be learnt. From the arborescent species of Wattles we might secure, by a judicious selection for copious planting, successively through all seasons masses of flowers along whole tree-lines or copses. Thus our Silver Wattle (Acacia dealbata) early unfolds its flower-trusses on river banks; then follows our Golden Wattle (Acacia pycnantha), to be succeeded by the spreading Willow Wattle (Acacia saligna) from Western Australia, and this in turn gives way to the flowers of the Black Wattle (Acacia decurrens) on our ridges; while the Blackwood tree (Acacia melanoxylon), as well as Acacia implexa, A. penninervis and many others, bloom later in the season, to keep up this imposing and grateful floral display, while A. retinodes remains ever flowering all the time. But for industrial purposes many of these Acacias become of far more than ordinary interest. Catechu, tanners' bark,* gum, galls, scents and woods of various qualities are obtained from them; others serve for hedges; but as regards oddness and strange diversity of foliage there is no other genus in the wide range of the vegetable empire which is equally remarkable. The harvest of seeds from such an array of showy plants of easy growth is usually most copious and valuable in itself. For scientific and yet gay aggregation the native genera Pultenæa and Daviesia, both familiar to us here, offer respectively 75 and 55 species; Hibbertia (including Candollea) furnishes over 80; Thomasia with Lasiopetalum together 50. I instance all these as grateful plants, enduring hot winds, and yielding seeds in copiousness for easy growth. Again—Oxylobium, Chorizema and Gastrolobium (if considered together as emanating from one general typic form) amount to 74, all beautiful, and some, especially the West Australian species, quite singular in foliage.

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* Good Wattle-bark is three times as rich as Oak-bark in tanning principles, and much quicker produced, and that in localities where no oak will thrive.

Turning to genera, numerically large in species, from which a botanic garden can copiously select for its conservatories, I might adduce Begonia. Professor Alph. de Candolle defines by his recent masterly essay in the Prodromus, the characteristics, carefully elaborated, of not less than 380 species; how far this number will be augmented, when once the mountain jungles of the whole of tropical Africa shall have been explored by phytographers or trained collectors, is quite beyond our surmise.† Even the infra-alpine regions of New Guinea and Borneo may add considerably to the number, and so perhaps even may yet Begonias be obtained from the unascended Mount Bellenden Ker of North-east Australia, into the jungle fortresses of which, as yet, no breach is cut. If we once possess any of these decorative plants, mostly well adapted for window culture, we can propagate them with the utmost ease, even from a mere leaf. Such plants, irrespective of their geographic interest, are important also, when the functions of a botanic garden towards horticultural industries are to be considered. The cultivator is glad to have fixed the botanic names and to know the respective native countries of the different species, particularly when, as in this case, the genus ranges throughout the tropics of nearly the whole globe.

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* From which a concentrated extract may be prepared.

† Dr. Hooker has since published 24 new Begoniæ from equinoctial Africa.

The epiphytal Orchideæ, which are the glory of all tropical jungles, from whence collectors can bring them away bodily with the greatest ease, are numbered by thousands. In the magnificent Belgian "serres" of Monsieur Linden are brought together already not less than 1200 species of these wonderful plants.

While such a collection is a gem in itself, a reward of circumspect toil and a triumph of superior horticulture, it at all seasons charms even the plain observer, either by the bizarre forms of flowers, or by their gaudy coloration, or by their imitative resemblance, or by their curious mode of attachment, whether to walls, rocks, wickers, fern stems, logs or any other substances.

Such an assemblage affords at all times ample material for original study and designing art, while its contemplation raises the taste and standard of horticulture, and instils an amount of information, which ordinary decorative cultivation fails to convey; indeed, a botanic institution should aspire to these higher aims. Again, to the proprietor, such a collection, by its increase in masses, can also become commercially one of quite a lucrative gain. Hence I allude to this specially in this industrial hall.

Perhaps it is not too much to assert, that every one of the existing ferns is worthy of cultivation. The delicacy and gracefulness of most is proverbial; the rearing of the majority is not surrounded with difficulty, even from almost invisible spores,* while pteridologists have already unfolded the astounding number of 2400 specific forms, numerous varieties uncounted (*vide* Hook. and Bak. *Synops. Filic.*). Yet recent searches over the small islands of the Samoan group have taught us how greatly this number of known ferns may yet be augmented, when once Central Africa, Borneo, Sumatra, New Guinea, Siam and other tropic countries, widely unexplored, shall have been fully traversed. The Angiopteris presented to you here from North-east Australia extends its single fronds often to a length of 12 feet or even more.

Of Passion Flowers now already 231 are on systematic record, far the greater number from the tropical regions of America.†

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* Imagine that a fern-tree, possibly as high as the Museum Hall, can be raised from seeds so extremely minute, that millions of them would not weigh an ounce.

† Dr. Masters, in *Transact. Linn. Soc. Lond.*, 1871.

We possess, as yet, but few of these graceful plants, and must persevere in our efforts of acquiring more of them, as well for the open ground as conservatories. These plants are not only quite as gorgeous as any of those which the ephemerous tastes and fashions of the day have brought into prominence, but they are infinitely more remarkable and instructive, besides far more lasting and grateful in culture. Several species, more or less adapted to our climate, yield the granadilla fruits, which yet ripen in the tropics at elevations 6000 feet high.

Almost every one, who possesses a plot of ground, maintains a garden in some form, or, failing this, rears a few window or verandah plants. But simultaneously every one, as a rule, evinces a desire of acquiring some more accurate horticultural information, and of becoming acquainted with some item or the other of knowledge relative to the plants around him. This applies, with equal force, to the native vegetation, by which we are surrounded anywhere. We can scarcely cast our eye on any object without meeting some flower or foliage, from the humblest moss to the proudest tree, about which an educated mind is desirous to be informed. A room, however modest, can be rendered more cheerful by a few flowers; the splendour and elegance which graces a ball-room would be deprived of much of its charms without floral gayness. What can be more lovely than the buds of purest white in bridal wreaths, when they adorn the happy brow? Who did not admire, in the fêtes for our charities, the garlands woven by tender hands, or the flower-bunches gathered with smiling faces? Or, if we wish to pay the last worldly homage to the departed dear to us, do we not seek for a few snowy blooms to press into the cold hand, or to carry to the last resting-place? In all the changeable events of this versatile life, whether the saddest or most hopeful, we are longing to find in the floral world some emblems for our joyfulness, as well as for our deepest grief. Ever sought, ever admired, at the happiest hours chosen as the silent interpreters of affection, and in the gloomiest moments as the symbols of woe, flowers seem identified with all the tender feelings and all the gentle sentiments of mankind. Can there be then more noble objects for our studies? or are we to rest satisfied with a mere instinctive recognition of their outer form, bare of real knowledge of any kind? One of the great objects, which a scientific garden is to fulfil for whole communities, indeed, consists in elevating the traditionary notions or the simple conceptions of plants to scientific cognisance and the highest educational standard.

In the oldest hieroglyphics, in the sarcophags of the mummies, in the Huenen burials, and indeed in all relics of the remotest antiquity, the historian has to trace plants, and is often led on by them in his archæologic researches. The physician must draw them hourly into use; the artisan, whatever may be his occupation, has daily to depend on them or their products; all our aliments are derived either directly or indirectly from vegetation; the very existence of the whole animal creation, indeed of man himself, is dependent on plants. There can be no wiser measure for general education, than to afford the easiest opportunity of gaining, at least to some extent, a scientific appreciation of these faithful and cheering companions of ours through life. Mark, when reflecting, how intimately the knowledge of the living plants is connected with the product, which they yield so beneficently for our wants. The artisan, who constructs the building, should be able to recognise in our parks the Spruce Fir, which furnishes him the deal for flooring; he would no less be interested in viewing, though here perhaps under glass, the Mahogany tree, whose wood passed for years through his hands. The chair on which we rest, the flooring deals over which we daily step, the pencils with which we write, the frames which enclose the pictures on our domestic walls, all these and thousands of other things surrounding us, are yielded by the vegetable world, and can become the objects of intelligent reflection and industrial teaching. The bloomy imitation of tapestry, or the flowery embellishments of decorated walls or architectural elegance, do they not call hourly plants to our mind? In the painters' landscapes, in the poets' ideals, are they not always among the foremost? And where can all this find a more vivid and a more easy interpretation than in a botanic garden true to its purposes? Few even of enlightened minds ever think, from how many different zones, from how many distant parts of the globe, all these materials of necessity and comfort have to be gathered. It is clearly the object of an institution, the meaning of which we now briefly discuss, to bring the sources of all these things before our contemplation, so that the observer may trace—by the impressive teaching of living forms, all mute, yet all telling a tale of their own—the origin of those vegetable substances, with which the demands of our occupation or the enjoyments of life bring us in constant contact. But shall we rest here? Ought not our meditation, when leading us from lifeless material to the wondrous living forms of vegetation, bring us nearer also to the ever-wise originator of the world.

> "All are but parts of one stupendous whole,
> Whose body nature is, and God the soul,
> That, changed through all, is yet in all the same,
> Great in the earth, as in the ethereal frame:
> Warms in the sun, refreshes in the breeze,
> Glows in the stars, and blossoms in the trees,
> Lives through all life, extends through all extent,
> Spreads undivided, operates unspent."—POPE.

The large collections, then, in a botanic garden, whether of growing plants or of museum material, are not amassed without serving important purposes, and not accumulated merely to satisfy transient curiosity. This may be shown by facts of vast number; let us note one or the other in testimony. As indispensable auxiliaries we want nowadays for studies in a botanic institution manifold collections, which, in fact, must emanate largely from the garden itself. For the full utilisation of such collections we need moreover to maintain a laboratory and ateliers of other kinds, to turn the riches of a really botanic institution to applied account. Besides, we require to fix all observations by lasting records, and render them, by issued volumes or by illustrations of pictorial or plastic art, accessible at all times. No sooner does a seed-grain germinate, than it can be utilised for research. The great De Candolle gave us in his *Memoires des Légumineuses*, the results of his observations on the embryonic development of one large tribe of plants. The writer commenced to trace the germination and early development of Eucalypts and some other plants, to gain in intricate cases of affinity additional data for diagnosis, and these kinds of researches admit of the widest extension in manifold directions. Be it remembered, for recognising the multiplicity of material, that our choice for culture in this clime is from 30,000 out-door species alone, even if varieties are left altogether out of consideration; and how much varieties represent in number may be recognised in the contemplation of the culture forms of a single species of Rose, of Verbena or Dahlia. You may perhaps reckon on 3000 species of trees hardy in Victoria, 7000 shrubs, 12,000 perennials and 8000 annual herbs—grasses and rushes to be counted with the two latter. After such an immensity of hardy material has been selected from for cultural research, we have not yet allowed for the endless number of plants, which we can shelter under glass protection, the extent of hospitality thus to be afforded to delicate strangers being simply depending on the monetary endowments, which at any time or place may be at command. The total of Australian Dicotyledoneæ, hitherto ascertained to exist, is 6500, and although in some instances the supposed species will collapse, there will be also some compensating access from new discoveries. The number of Monocotyledoneæ is also comparatively great. Should we not largely surround ourselves with our own native plants, handsome and instructive as they are. The range of cultivation in our state garden has at times been already extensive. In 1865 seeds were collected of 700 species of trees and shrubs in the garden; seeds also of 170 kinds of grasses, of 1100 herbaceous plants, and of 80 species of ferns. Many of the species thus raised became also amply dispersed. It is not too much to affirm, that during the many years of my directorial administration of our young establishment, hardly a day has passed without some industrial plant having been distributed, and information on its rearing and uses having been afforded. The increasing population demands increased attention. I have just spoken of the thousands of native plants, recorded in volumes of our own; they gained at least a share of their contents from locally cultivated plants. Let me ask, whether we should not find the principal plants of our own continent brought before us in cultivation, for systematic as well as other studies? They are indeed excellent indicators of clime, of geographic features and geologic structure. You all have heard, for instance, of the Polygonum swamps, so often referred to in the works on Australian exploration. Assuredly it is of interest to possess in a botanic garden the tall, wiry bush, which occupies in intricate masses the clayey mud-flats of the interior, and which indicated to many a traveller, when almost perishing, the place of relief. Should we not be able to show in culture the poisonous herbs, against which the squatter as well as the explorer must guard? Of the 110 Saltbushes of Australia, some are ascertained to be eligible as culinary esculents; the majority of these plants are of high value for sheep-pasture. These, with other salsolaceous plants of other countries, I should certainly like to see well represented in a scientific garden, as well for instruction as for test. Very many plants can be best examined for characteristics when in living freshness. The number of Australian Villarsiæ known to R. Brown in 1810 was only two or three; chiefly through my own exertions we are now acquainted with seventeen; the delicate and often fringed membranes of their flowers, while they deliquesce in museum specimens, can be seen in our tanks at a glance. You can recognise the loveliness and above all the irritability of the Stylidia, of which we doubled the number since the time of R. Brown,* only in the living state, the column of the flower snatching over at the least touch, a fact which even the keen eye of the natives seems to have frequently overlooked. It was largely through the exertions of our botanic department that the twelve species of Myoporums and Eremophila, recorded in R. Brown's Prodromus, were advanced to 60 in number; and it was through similar scientific exertions that the 70 Goodeninaceæ became increased to 180, the majority highly deserving of culture, and many available for medicinal use.

The command of large collections of museum plants, commenced by my personal field exertions more than thirty years ago, gave here local advantages for affording also to correspondents in other colonies a fuller insight into the characteristics of the vegetation of their respective localities. Among those who availed themselves of such facilities for occasional consultation, I count a gentleman of the Survey Department of Sydney, R. Fitzgerald, Esq., whose object it was to obtain, in doubtful cases, the names of plants for a series of drawings, prepared with ingenious skill and talent by his own hand. Ever anxious to lead such efforts into the best utilitarian channels, I suggested the publication of these illustrations in a weekly journal. With a readiness, which reflects great credit on the scientific taste of the proprietors of the *Sydney Mail*, space is to be conceded for one plant at a time, as a preliminary issue in that valuable periodical, with an ulterior object of re-issuing the plates and descriptions in a connected form, as suggested in the first instance. Here now we have before us the first illustrations, to be followed, in regular succession, by others, an electro-plate to be used in final republication. It is superfluous to point out, that such efforts will likely lead to imitation, and will instil an amount of lasting information, the extent of which we cannot calculate or foresee. From larger works, elaborated in great scientific institutions, devoted to the accumulation and study of plants, will always emanate special publications, and among them in due time local floras of each populous locality. The sedulous and ingenious zeal of Dr. Will. Woolls, of Parramatta, has thus already provided for the requirements of that spot. To promote objects of this kind is within the legitimate pursuits of a botanic garden; and it would be vain to argue, that the interests of industrial artisans are not also involved in all these pursuits. I have a vivid remembrance with what an enthusiastic avidity many a student commenced his scientific collection of plants from gatherings in a botanic garden; how he sought for correct appellations, traced the indigenous localities of any species, endeavoured to understand the particular relationship of plants, and commenced to arrange systematically what he had gathered. Or I may have witnessed how the spare hours of a youth, eager for phytologic information, were spent, not in unprofitable plays or planless strolls, but among the flower-fields of free nature; how he soon recognised any additions to his collection, and greeted any rarity or novelty with the outburst of absolute delight. Soon an impetus to more extended observation is given, kindred spirits are drawn into co-operation, while recreative pleasures are advanced to sound philosophic speculations or applied knowledge, and thus simultaneously a pure fountain of never-ceasing joys, or an everlasting spring of utilitarian riches, is opened. Such was the first commencement of the luminous career of some of our great naturalists, and such was also the first origin of some of the most important museums of plants.

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* Now nearly 100 Stylidia are known.

As means of education the collections of a botanic garden, whether exhibited in their vivid freshness, or stored for preservation and reference, may exercise a vast influence. It is not too much, when I assert that even the study of languages and geography, through scientific garden plantations, may be fostered, and this in a manner more pleasing than in most other forms, just as numismatic collections are among the most lucid and impressive exponents of both history and geography, irrespective of ethnologic and linguistic researches; so much so, that coin cabinets, as auxiliaries for superior teaching, should not be wanting in any leading pædagogic establishment.

A few plants speak often more strikingly for the nature of a country than a mass of pages of descriptive explanation; or a handful of flowering branches, gathered on an unknown shore, indicate often at once capabilities for rural productiveness and settlement.

No less important is the relation of plants to geologic structure and climatic conditions, and we must insist on the collateral study of all these branches of discipline in the true spirit of the great writer of *Cosmos*, if we wish to assign to the knowledge of plants its true value. Only within the last weeks it fell to my lot to demonstrate, from material placed at my disposal by the secretary of the Mining Department, that in perished forests, where now the town of Haddon stands, deeply buried under superincumbent strata, once lived in this very colony a tree, closely resembling that of the Satinwood of the hottest part of India (Chloroxylon).

I have heard it often remarked by thoughtful and circumspect visitors, when they passed through our Botanic Garden, that now, for the first time, they had learnt from whence naturally came some particular plants, which they had reared for years at their dwellings; or that they had remained until then unaware of the name, or the native locality, or any other knowledge concerning plants, with which they had by sight long been familiar. Perhaps even it is not too much to contend, that no observant visitor can pass through a scientific garden, be it ever so often, without taking with him in each instance some new instructive information.

All this must largely bear on technology. Unquestionably any intelligent mind is pervaded by the idea, that the study of plants must have important bearings; but often this is only a vague impression, and very few may really have a comprehensive persuasion of that actual relation which exists between botanic inquiry and utilitarian application even of the current day; much more difficult then must be the recognition of all that which is only foreshadowed in a dim future. And yet we cannot cast our views around us without meeting, in every direction, objects derived from vegetation, if not plants themselves, drawn into applied use. From the strong beams of a building, or the tall masts and weighty planking of a ship, to some of the most delicate articles of turnery, we see brought before us woods from often widely-distant countries; or we notice, from the stout ropes of rigging to the most tender threads, woven into wearing apparel, the utilisation of basts from plants, which perhaps flourished in different zones and were reared by different races. What can be more instructive then, and what can more readily lead to new local industries, than a special display of such fibre plants, or any other group of utilitarian plants, in distinct areas of a botanic garden, where we may view them all at a glance, and from whence they may become disseminated? The work of a botanic institution for such purposes should, however, not be lightly disturbed, its means scattered, or its collections imperilled. It requires much watchful toil and research to bring together the material for large instructive collections, which, if even only in part sacrificed, cannot be completed again without both laborious care and renewed expenditure.

Here in this hall I would ask, is it not the artisan who is specially interested in such collections? But the efforts to furnish or extend such means of teaching should not be ennarrowed by bondage, nor be discouraged by want of appreciation and sympathy.

To exemplify yet somewhat more the duties, which devolve on a botanic garden, for attaining the various objects set forth, it may be instanced, that its administrator must be extensively acquainted with the known vegetation of every part of the globe; he is thereby enabled, in his scientific relation to correspondents in all civilised countries, to secure by interchange or otherwise additional treasures for the institution entrusted to his care, and he is thus armed with the capability of recognising the real value and significance of the riches which in his institution are already accumulated. He further must be conversant with the nature of his new acquisitions, to assign to them their scientific place in his collections, to identify them for ascertaining their names and properties, and to provide for them the varied requisites for their culture, which he alone can fully understand. Only by long professional studies, which qualify for the administration of a scientific garden, is it rendered possible to discriminate between the known and unknown, to record new physiologic facts, to circumscribe additional genera and species, to trace out novel qualities, whether medicinal or chemical, whether technological or rural. Information by these means will necessarily exercise its influence in a professional department, and the reflex of this influence will be the diffusion of special knowledge in a manner best adapted to the requirements of time and place. So far the path seems clear enough, yet grave obstacles may arise to impede or frustrate the progress; the means of an institution may be quite unproportionate to the ever-increasing demands made on it, and the whole of an establishment may suffer in the inadequate struggle. Natural difficulties may supervene, occasional droughts or floods may imperil or destroy the work of years. There may not even be water from inexpensive sources to irrigate arid declivities, or to convert rocks into spots of fertility. Quiet, inostentatious arrangements may in many other ways be marred, not to speak of the impossibility of coping with the elements. Well-matured plans, involving years of preliminary action, may become suddenly overthrown; and the detriment thus sustained is then not only one of the institution itself, but one of whole communities, or perhaps even of science at large.

Unfortunately it is not everywhere that the originator of a horticultural institution for botanic purposes can exercise his judgment in the choice of the area; he finds it, as a rule, selected beforehand, and to the advantages of ready access of the multitude most other considerations have to give way. In an ideal perfectness of a botanic garden we would seek to command the utmost diversity of soil, from the heath-moors to sand-drifts, and from rich clays to humus deposits; and we would wish to have within our reach geologic rock-formations of various ages. But how rarely are such advantages attainable in one area! Local climatic influence will also frustrate largely cultural successes, without costly artificial means for imitating the conditions on which the growth of many a plant entirely depends. Few botanic gardens have, in this regard, the rare facilities of the one of Buitenzorg in Java, which in its several branch establishments on the slopes of a high mountain-range enjoys the means of bringing to perfection as well species bathed in the vapours of the hottest tropical jungles, as also such as only prosper on alpine heights, or such forms of vegetation as withstand the vehemence of icy storms or the rigour of protracted burials under snow, and all this in a comparatively close proximity.

When an important plant has once been introduced or tested, a task in which a botanic garden must always take a leading share, then rural enterprise and private capital are expected to advance the cultivation and utilisation of such a plant to commercial dimensions; or in particular cases the state may fairly aid by affording the necessary special means for successfully establishing such a plant as a new source of wealth to the country. I wish we could here do for the tea plant what the Governments of British and Dutch India have done for the formation of Cinchona plantations in the warm, temperate regions of the Indian mountains. The officiating director of the Botanic Garden of Calcutta, C. B. Clarke, Esq., M.A., gives, in his report of April of this year, the number of Peru Bark plants in the Bengal Government plantations as 1,741,474, irrespective of seedlings and cuttings in the nursery plantations. The established plants on Government ground of Cinchona succirubra (yielding the red bark) numbered then 1,233,715; those of C. officinalis, 440,000; other species existed in smaller number. Be it remembered, that this new culture was commenced in British India only a few years ago. But there large sums are specially granted for this new branch of industry, which sums, if we consider the cheapness of Hindoo labour, would need here, for similar purposes, to be proportionately enlarged to secure equal successes. For the thousands of Cinchona plants, kept in my brush shades, as yet the reservation of the needful mild forest plots, and the special fund for the maintenance and the multiplication of such plants in the woods, has to be obtained. The yield of seeds by Cinchonas is abundant after a few years, and by these means the subsequent increase of the plantation is easy, and not involving large expenditure. To private settlers in our own forest gullies and in the other Australian colonies Cinchonas have been furnished; in open gardens near Sydney a few scattered plants have flowered this year, they being in that genial climatic spot not imperilled by frost.

If the tea plant, both of China and Assam, was first of all largely raised in Australia by myself; if I placed it before the public in its growing state; if I drew repeatedly attention in public documents to the importance of its culture; if I prepared the first samples of Australian tea in our Botanic Garden for great industrial exhibitions here and abroad; and if, moreover, I annually distributed tea-plants and even seed to an extent not altogether inconsiderable, then I do think that I may rest satisfied of having fairly carried out my duty; I cannot step beyond this. Private enterprise and commercial capital must do the rest to advance also this culture here to industrial dimensions. The long-continued prejudice, that tea cannot be cultivated with mercantile remunerativeness beyond the boundaries of China has at last been overcome in the Southern States of the American Union, where a commencement has been made with the production of tea from indigenous fields. At Assam, also, tea is since some years largely cultivated by English planters, to one of whom, Mr. Bruce, formerly of this city, I am under obligation for his disinterested liberality of providing seeds in large quantity at my solicitation, while I owe the first large consignment of China seeds to the generosity of Sir Hercules Robinson, who sent it about a dozen years ago on my application. I fancy that tea plantations, even if made in first instance only for raising local supplies of seeds, would be profitable, the transit from China or Assam being difficult on account of the short vitality of the seed.

It is well known, that in China and Japan hitherto, with an unalterable obstinacy to any changes of method, the preparation of the tea-leaves is carried on by primitive processes of unaided manual labour, without any mechanical appliances of machinery. But what would be the onward course of literary intelligence, if we had still to adhere to the original manual operations under which writing and printing paper was produced, or if we had continued reluctant to adopt the mighty steam power, to speed and cheapen the production of print, when nowadays even the simple folding of printed sheets is rapidly done by machinery. Beet sugar, at its present price, could not possibly be produced without the steam-engines of factories; and there is nothing to prevent us to call that great mechanic agent also to our aid for heating and curling tea-leaves. Also in this respect we must emancipate ourselves from foregone conclusions.[*] The demand for tea as a commercial commodity is something astounding. The importation into Britain alone has been latterly about at a value of ten millions sterling annually; the consumption is even rapidly increasing. The process of establishing tea-fields is simple and easy. In North America the plants are placed six feet apart, each plant yields about one pound of tea annually, or about four pounds of fresh leaves; the gathering extends over about six months there. To foster tea-culture is to advance the great temperance cause.[†]

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[*] On explaining to Mr. G. Joachimi, C.E., of this city, all the details of preparing tea-leaves for mercantile commerce, he has constructed on my suggestion an apparatus, to be worked and heated by steam; this will require, according to his opinion, only two men for performing the work which according to the present Chinese method would occupy twenty-five men. The mechanism, so constructed, provides for cutting wood for tea-chests as a bye-work.

[†] The imports of tea into the United States for some of the past years were as follows, according to Consul T. Adamson, viz., year ending June 30:—

1856-57	25,292,100 lbs.
1858	29,255,300 lbs.
1859	30,173,100 lbs.
1860	31,662,400 lbs.
1861	28,189,300 lbs.
1867	39,892,658 lbs.

The importation of tea into Britain for the seven months of each year, ending July 31st, was—

1869	67,648,588 lbs.	value	£4,904,777
1870	79,384,477 lbs.	„	£5,263,836
1871	91,753,906 lbs.	„	£6,030,556

For the whole year—in 1864, £9,338,760; 1865, £10,044,462; 1866, £11,208,815.

Foreign select Oaks, or rare and important Pines, may have been introduced by the thousand, and legions of ornamental or industrial plants may have found their way from a botanic garden, directly or indirectly, into numerous cultural spots, and may largely contribute to grace already even many extensive parks; yet after all the extreme efforts of sedulous skill, and after an institution may have lavished its treasures with unbounded generosity, it still may find itself forsaken even by those on whom it had most claims. Here is before you the noble Dye Pine of Nepal (Pinus Webbiana). It fell to my lot to raise it in Australia first of all in masses, more than 20,000 seedlings having been reared in my nurseries two years ago. But the growth of this noble Spruce is slow. It requires three or four years before a seedling is strong enough to be trusted out. For all the patient care thus bestowed, and for all the foresight thus displayed, there can only be results after rather a long while, especially if even the facilities for culture are locally much impaired. Moreover, it is in the forest lands only where numerous plants, which I have introduced, can attain to perfection. It would, for instance, be hopeless to attempt growing the American Cranberries, Huckleberries or Blueberries, or the English Whortleberry, in the Melbourne Garden, with a prospect of a copious yield of fruit. In our Alps we have extensive sphagneta for many of these kinds of plant, but scarcely an edible fruit of any kind grows naturally on our snowy mountains. In Germany and some North European countries Bleeberries are brought as extensively to market as Strawberries. The Honourable the Commissioner of Agriculture for the United States, General Horace Capron, states in his report for the year 1869, that the culture of the American Cranberry (Vaccinium macrocarpum) is annually much increasing in some of the states; boggy sands of the savannahs, cleared of cedar brushes (Taxodium distichum), being chosen for this culture. In New Jersey about 1800 acres are now in bearing,* and about 4000 acres more were up to 1869 planted with Cranberries. The profit on the capital thus invested is from 25 to 50 per cent. annually. One grower realised in eighteen years, from only ten acres Cranberry land, a fortune of £40,000. In the United States many thousand people are employed almost exclusively in picking of this and kindred fruits. In June commences the harvest of Strawberries; a month later follows the Raspberry; then come the Blackberries; in August commences the gathering of Whortleberries; after that the picking of Cranberries is proceeded with, which extends to November.*

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* Producing 150,000 bushels in 1869, worth 12s. per bushel, therefore £90,000 the year's crop in that small state.

The miners, in prospecting through the ranges, might scatter the seeds of berries of those kinds along watercourses, or set out plants along rivulets or springy forest spots, from whence, when left to themselves, they would be sure to spread. The explorers of the interior, by strewing a few seeds of Acacia lophantha, Casuarina quadrivalvis or some Eucalypts over their camping ground, might yet more permanently indicate these bivouacs than even by burning or cutting letters in many trees. In all this a botanic garden has a fruitful field for exertions. I endeavoured to naturalise the medicinal Squill on our sea-shores. Lately the American species of Sumach have come in successful competition with the Sicilian Sumach, the species from which gatherings are made in the United States being chiefly Rhus glabra, Rh. typhina and Rh. copallina; all rich in tannic acid, all to be seen in our botanic garden. In translocations of this kind, which, under the sanction of usage, we are accustomed to call acclimation, we are expected to take a leading share; the former is the apter term, inasmuch as the possibilities of changing constitutional endurance to clime are restricted to narrow bounds. I should have spoken of the uses of a botanic garden as a horticultural school, of excursions to emanate from it into the flower-fields of the near environs; of the aid which ours has afforded to provide the festive boughs and decorative flowers at thousands of *fêtes* for our charities; but our time has drawn to a close. I intended to have also spoken of "the marvels of vegetation," which it might display, but must reserve this theme for a special lecture. Still this I would say, that all teachings should be in such a form in our own state gardens as not to encroach on the functions of our famed University, which has made already early and special provision for phytologic instruction.

For toxicologic experiments in a botanic garden the various poison plants become of importance, irrespective of the guardianship, which the display of these plants in a living state so instructively exercises. Investigations of this kind require lengthened attention, the separation, analysis and identification of organic poisons being surrounded with far more difficulty than the examination of metallic or other inorganic substances. Besides, the development or intensity of the deleterious principle depends often on local causes, which are not always within ready range of observation, or perhaps even involved in mystery, such as physiology and chemistry have hitherto striven in vain to clear away. The so-called Cape Weed, for the presence of which I am not responsible, as it had already irrepressively invaded some parts of Australia as early as 1833 (Cryptostemma calendulaceum), was recently subjected in my laboratory to examination, with a view of ascertaining whether any chemically separable active principle might produce the violent purging, terminating in acute and often fatal dysentery, to which flocks occasionally become subject, but the investigation gave negative results. The deleterious effect arises therefore either merely from mechanical irritation and distension, when sheep have gorged themselves with this weed, or it may be traceable to a locally-developed poison, which in ordinary circumstances does not exist. The latter was ascertained to be the case by my own experiments as far as Swainsona Greyana, Swainsona lessertiæfolia, Lotus Australis, Gastrolobium bilobum and perhaps Stypandra glauca, are concerned. The two former cause in some localities cerebral affections in horses and other pastural animals, terminating in death; but the cultivated plants were found harmless. Gastrolobium, with some species of Oxylobium and Isotropis, the bane of the heath pastures of West Australia, has hitherto baffled all efforts to detect an antidote, but one of the most dreaded species, Gastrolobium bilobum, proved here in cultivation inert. Desert specimens of Lotus Australis produced in my local trials deadly effects on sheep, while our garden plant or the fresh herb from the sand shores of Port Phillip showed themselves innocuous. Stypandra glauca is reported to produce complete blindness of sheep in some districts of West Australia, the eyes, it is said, assuming a blue tinge throughout. Unless this grass lily has been confused with an allied and externally-similar weed—namely, Agrostocrinum stypandroides—we have again a plant, which with capriciousness has hitherto baffled our toxicologic experiments. Anguillaria and Burchardia, which early in the spring sprinkle their pretty blossoms so universally over the pastures of the whole of extra-tropic Australia, produce, so I have ascertained, innocuous bulbs, although belonging to a tribe of plants which includes the dreadfully-deleterious Veratrums and Sabadilla.

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* Gaylyssacia frondosa et resinosa (American Huckleberries). Vaccinium vacillans, Pensylvanium et corymbosum (Blueberries).

All this shows that an ample field for observation is also open for us in this direction, and this more particularly in a young country like ours. We are no longer in the earliest youth of our colonial existence, when the few scientific questions, arising then in very small communities, could receive at long intervals their answer from the urbanity of leading European authorities, on whose professional advice or scientific opinion Australia however had no claim. But in the vigour and celerity of our colonial advancements we can afford no longer to wait the many months, which must elapse, before on every question the needful scientific information is obtained from abroad. Indeed, as might be expected, the applications for advice to a botanic department are now of daily occurrence, and ever increasing with the population and its varied enterprises. A central institution for phytologic information requires to be maintained among us somewhere, whether in this metropolis, or in any other city of Australia, may perhaps not be of great moment; but to build up such an institution for all these colonies, the local efforts here have not been altogether insignificant. The integrity of a well-constructed whole, on which so much forethought has been spent, should however not be lightly disrupted; or a carefully-organised department, of whose meaning or obligations but few can really be aware, should not be suffered to be impeded in its progress.

A botanic garden, which cannot afford to maintain at least one collector in the field, must be regarded as a very imperfect institution, especially so in a new country. For brisk interchanges particularly such material is needed as has amply the charm of novelty. Should we not also take an honourable share in unfolding the natural productions of the globe, especially when novelties or rarities are here almost within our grasp, and when assuredly the investigation of such is calculated to advance as well the interests of technology. The total of the territory of Australia, not yet traversed by exploration, may be compared in extent to the united areas of Britain, France, Scandinavia, Germany, Austria, Italy, Spain, Portugal, and Greece, and may therefore be estimated almost equal to extra-Russian Europe. It may be well imagined how eager the writer has always been to send emissaries into those wildernesses, more particularly while exploration and occupation progresses. New forms of plants require to be elucidated, the range of the species needs to be determined, the geologic relation of the different specific forms has to be traced; and it would be little short of blindness, were we not to admit, that industrial interests would be promoted at the same time. Even part of the unexplored coast of New Guinea is at no greater distance from Somerset at Cape York than Launceston from Port Phillip, and yet there are on that coast, within sight, snowy mountains as yet unascended. Even if a collector from our botanic garden could be pushed into that grand island, we would perform legitimate and honourable work, and might attain great results at but modest cost.

In some parts of Europe the fashions of horticulture have recently undergone some changes again, so far as to render the growing of flowers in masses, or bands, or decorative figures less predominant, as this extremely artificial culture is giving way largely to the far more natural one of picturesque or scenic grouping. I advisedly do not apply to this system of planting the term "subtropical gardening," which is yet retained in the excellent book published this year by Mr. William Robinson, of Kensington, who has contributed by this and other works (such as the one on the gardens, parks and promenades of Paris) so much to ennoble horticulture to simpler natural grandeur, and lead it to higher scientific tastes.

With still less logical propriety can the appellation of landscape gardening be chosen for this process of scenic ornamentation or group planting, as we comprehend something far more extensive by a landscape than the ordinary limited areas of gardens or even of parks. Call it whatever you like, this novel system is the very opposite of geometric or formal decorative planting; all these manners of culture have advantages of their own, more particularly in relation to special circumstances and requirements, educational, experimental or otherwise; these various cultural systems might even in some instances and to some extent be advantageously blended; but while they may all be represented in a botanic garden, the formal decorative planting or the cultures for exclusive ornamentation should there at least not prevail, but be made subservient mainly to scientific objects. Much in respect to bedding flowers and other simply decorative planting may be fairly left to the gardens formed for private entertainment and pleasure. Consider only, what is there to show after the season's expense and toil, when the gorgeous ribbons of almost endless length have faded away, or when the starry or other fanciful ornamentation have become blighted? Undoubtedly there was magnificence, but it was transitory. True, portion of it will naturally revive, other portions may be restored with little cost, but the main restitution of such floral displays on a gigantic scale requires expensive renewals, for which the state means, more particularly of a young colony, ought in early days to be too precious. I hold, that in a public cultural establishment, even in older countries, its endowments are more legitimately employed by devoting them to produce works of permanency and utility; not however falling into the other extreme of shutting out altogether ornamentation in its less expensive form. I further hold, that attractiveness in a young garden or park should commence in providing for befitting fencings, passable drives, reclamation of swamps, effective water-works, security against floods, shelter against storms and primary conversion of tracts of wildernesses into useful and reproductive verdure. We may gain the transient acclamation of a few of the less thoughtful, if we provide mainly, though only temporarily, for gaze, neglecting all that is lasting or urgent, or all that is scientific or industrial. But incontestably a reaction of public opinion will ere long set in; there will be little or nothing to show for much of the expenditure of years, and a just and resentful censure will sooner or later overtake us. Do you not think, that even a private proprietor will view after a time his collections of palms, which from year to year increased in value and also in ornamental grandeur, with far greater pride than his remnants of ordinary flower-beds? Will he not compare with infinitely more satisfaction the imposing forms of his inexpensively upgrown pines, from which he can harvest even the seeds, than the decayed relics of short-lived plants, which, however pleasing they may have been in their ephemerous glory, did involve probably a far greater outlay for maintenance than his lasting tree plantations? If means will allow it, let *all* these kinds of garden treasures be simultaneously maintained, particularly as the herbaceous plants provide a sight at once. If it must be flowers mainly, then let it be largely Cacteæ, Begoniæ, Aroids, Scitamineæ, all yielding flowers in the true sense of the word, for glass accommodation; and let it be the hardy diversified plants already named in the earlier part of the lecture, which, while they are as gorgeous as any, are not ephemerous, increase in value, convey a vast amount of instruction, and lead horticulture to a higher flight.

Reverting to the noble taste of scenic group planting, let us acknowledge it as one capable of being developed into the most picturesque magnificence, into the most grateful yield, into the most bloomy features, and above all, into the most extensive instructiveness. Many horticulturists of eminence have shown already, that for impressive groups of plants, even in colder countries, we can dispense with sub-tropic forms, although for half the year they may still more embellish the vivid and graphic effect by bringing Tree Ferns, Palms, Yuccas, Melianthus, Bamboos, Agaves, Fourcroyas, Cycadeæ, Papyrus, tall Gahnias, Cardylines, Cannas, Richardia, Acanthus and the great Mexican Composites (Ferdinanda and Montagnea), and other spacious or conspicuous and not absolutely tender plants, from conservatories there to the open ground, with a view of enhancing the effects of such groups as may permanently be constituted by the hardy Pines, Ailantus, Gynerium, Heracleum, Ferula, Donax, and even ordinary Artichokes and Helianthus; or the sown Ricinus, Sorghum and Maize; or the nobler species of Rheum, Polygonum, Gunnera, or the tall Kamschatka Angelica, all available even in colder zones for unprotected garden spots.

But what shall I say of our operations here and our facilities in this respect, when the larger share of Middle European conservatory plants, from a Norfolk Island pine to an infinite number of other plants, can be trusted out by us at once under a genial sky into the open air? How would such facilities be turned to account by eminent horticulturists of scientific knowledge and refined taste, if in Middle Europe the clime allowed of it? In this respect a botanic garden can fulfil also here its duty, by introducing the nobler forms of plants, and by educating the community to higher horticultural conceptions. You need not exclude the Rose, which we all appreciate as the queen of flowers; you need not banish anything else that is brilliant or gay or odorous, from Bulbs and Carnations to Petunias, Pelargoniums or Dahlias, or any other favourite flower; but let us allow also for the higher decorative and utilitarian work of horticulture a fair scope. Let us study to embrace all that is attractive in any form, whether native or foreign, into one grand whole of magnificence, without singling out a few transitory plants for almost exclusive culture, and without sacrificing to a monotony, which may become finally comparable to the Tulip monomania of a darker age, all loftier cultural interest, all that in this direction is elevated and great.

So vast are the treasures which floral plenty is shedding out before us, and so abundant and diversified are the gifts which from all zones are poured into the rich gardens of the centres of commerce such as the British metropolis, that it would be a wise measure to endow a state garden like ours so far as to secure and to retain exclusively the talent and industry of a professional horticulturist for selecting in London for us, to watch the arrival of every new plant of importance, to transmit it under vigilant care, and to conduct our interchanges there and from thence on a vastly-extended scale. The amateur cultivators and the traders in plants, as also the administrators of public estates, are alike interested in such a measure, so long as it is not with the object of monopolising with selfish views of local aggrandisement the riches thus acquired, and so long as it remains our aim to turn these acquisitions to an enlightened account for whole communities.

It is unquestionably of importance to provide in any scientific garden from time to time accurate catalogues of the contents, quite as much as an inventory as to guide information and to regulate interchanges. But this is a work of such magnitude and constantly recurrent additional labour, that even the grand establishment of Kew has shrunk from the task of issuing an index of all its plants since a long series of years. Not only the difficulty is encountered to identify the plants with specific accuracy, for which purpose they must be examined while in flower and fruit; but moreover such catalogues become almost instantly incomplete or altered, partly because annuals are a very uncertain possession, partly because we cannot imitate all the conditions under which so many plants of the Alps, the moors, the heaths, the saline steppes or the tropical jungles, are naturally thriving; hence a number of species, capricious in their mode of growth, are apt to perish in culture, however much care may be bestowed on them. Then again daily new access is gained in any great horticultural collection, while in the process of discovery some changes will continually occur in the nomenclature, until all plants of the globe shall have been fully collected and exhaustively studied. Under these circumstances of adversity, I raised the question among leading directorial colleagues in Europe, whether by united efforts we could provide for the publication of an universal catalogue in annual editions, or at a regular interval of a few years. It appeared to me, that just as all navigators possess one nautical almanac, prepared for them annually, so all horticultural establishments, those formed for trading purposes included, should enjoy the universal use of the best index which at the time can be compiled. From such standard list local catalogues could be re-issued whenever and wherever necessary, while each institution may irrespectively maintain its standard copy complete for reference to the latest day.

I revert once more to the forming of test plantations as prominent among the obligations of a scientific garden. What for instance can be more interesting than a collection of fibre plants, kept together in cultivation, to watch their respective endurance to climate, their rate of growth, their required nourishment, their proportion of yield, or to ascertain the strength of their products, the adaptability of the latter for various textile fabrics, their mercantile value and commercial demand?

The subject of fibres is one so large and so momentous, that we must discuss it some evening specially in this hall.* A good many kinds of fibre plants were grown experimentally under my direction and subjected to various tests, recorded in the documents which emanated from the successive great Exhibitions. Some of the results of my experiments on strength were given in the descriptive catalogue of Victorian sendings to the Sydney Exhibition of last year. But such tests must be continued or extended. I should therefore like to have here under access many of the numerous fibre plants which are not yet even known beyond their native countries. The administrator of the Botanic Garden of Calcutta in his official report (of April of this year) alludes to no less than 14 new fibre plants, all allied to the Grasscloth, from Upper India alone. He thoughtfully observes:—"It is however not the excellence in fibre that is necessary to recommend a fibrous plant as economically valuable. The principal value of Jute (Corchorus olitarius and C. capsularis) is that it can be easily prepared," as it must always be our endeavour to liberate the fibre by mechanical means, but not by chemicals or heat, from the adherent other tissues. Mr. Clarke mentions as the most promising of these new fibres that from Villeburnia integrifolia, a small tree from Khasia, which with some of the other recommended fibre plants will probably prove hardy here. He regards the Villeburnia as the strongest of all the Sikkim sorts, it being used there for bow-strings. In its whiteness and its fineness of texture it seems to surpass even Rhea. This fibre can be more easily cleaned than any of the others tried on this occasion, and the bush yielding it is thought to grow like Osiers.

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* In an index published by the Commercial-Industrial Museum of the Maison de Melle, near Ghent, the scientific names of 550 kinds of plants, yielding textile fibre, are given.

Maoutia puya seems the second best in value; it is marvellously strong, and provides the Lepchas with the principal material for their native cloth. Again from Debregeasia velutina many of the Assam tribes obtain their cloth.

Of the Jute fibre there were imported from India in one single year into England no less than 60,000 tons. The United States of America imported also about 50,000 tons in a year, there realising £60 and more per ton, the importation in 1865 having been 91,549,800 lbs. Regarding fibres, we can learn here, by test culture through the year, during which months the best flax crops can be obtained, what varieties of cotton can yet be cultivated to advantage in our soils and in our latitudes, cotton culture in North America terminating with the 38° N. In short, there ought to be, in a scientific garden, representative plants of any important fibre hitherto drawn into industrial use. So it should be with important starch-plants, dye-plants, oil-plants, fodder-plants; so it should be with any species adopted in medicine. Remember only the pretty Lupin plants, of which about one hundred different species are known; how decorative are they all, how valuable, and so recognised since antiquity, as fodder-herbs and for green manure; how little comparison has also yet been instituted between the value of their species of the Andes, of British Columbia, of the Mediteranean regions or California. There are various kinds of Arrowroot plants, different in their degree of hardiness; there are oil-plants, which ripen a crop in three months, such as the Ramtil or Guizotia. All these deserve to be tested, and to be kept prominently before the eyes of our colonists.

Manures in their varied constitution and application require also experimental tests. Diseases of plants, in their increasing multiplicity, need to be carefully traced and elucidated, for which purpose the means of a well-sustained botanic garden ought to be available with legitimacy. Be it so far enough. But there is also something inexpressibly charming and recreatively instructive in viewing a very large assemblage of plants from all the different parts of the globe, scientifically traced to their names and origin.

But while devoting our energies and resources to the primary objects of scenery, we need not disdain those ornamentation-works which serve to embellish still more a stately structure. We can build grottos, if our means admit of the conveyance of rocks from the distance. We can raise islands, and convert swamps into lakes, whenever the resources of a young establishment are no longer taxed with still more important obligations. We can have fountains playing in all directions, whenever our botanic garden can participate in that supply and pressure of our great waterworks which is allotted to other suburban parks. We can raise statues also, to glorify monumentally what is noble and great. We can draw banded flowers through smooth and verdant lawns with the utmost of gaiety. But while attempting all this, we should never lose sight of the still higher objects for which a botanic institution is founded; otherwise, while trifling away slender means on perhaps even trivialities, we have failed to afford our early guidance to lasting prosperity or progressive and enduring advancements; and yet the accomplishment of this alone is an herculean task.

Rest assured a garden so conducted, as to fulfil its true destination, will never fail to provide in large measure the purest of enjoyments and the amplest of comfort also.

The sufferer, who may watch the varied autumnal tints, will he be less cognisant in a garden of science how frailness finally prevails in all organic structure? Or when contemplating the forms of plants arranged by the rules of knowledge, will he feel less influenced to seek consolation from them? For, surrounded by the yet expressive and imposing sceneries, he may trace, here above all, how life, embodied in endless forms, is passing through its allotted worldly stages, finally only to perish; and so he must also learn to resign himself, with all else that is mortal, to a higher will.

"Though wrapt in clouds, yet still and still
The steadfast sun th' empyrean sways;
There still prevails a holy will—
'Tis not blind chance the world obeys.
The eye eternal, pure and clear,
Regards and holds all beings dear.

For thee, too, will the Father care,
Whose faith and soul in Him confide.
And though the last of days it were,
He calls thee early to His side;
His eye eternal, pure and clear,
Thee, too, regards and holds thee dear."

GLADSTONE, FROM KIND.

Though the true destiny of a botanic garden should be maintained then with some rigour, be it far from us to withdraw those sources of pure pleasure which scientific refinement offers there to a still higher degree. Indeed, if ever we attempted to restrict an institution of this kind to absolutely utilitarian purposes, we assuredly would find the separation or exclusion of simple means of enjoyment a total impossibility. The avenues, formed of timber trees, as forest representatives from wide distances, will afford to the strolling visitor no less of cool umbrageous expanse than if raised for his recreation only. The colouring changes of the vegetation throughout the seasons, or the varied periodic hues of foliage and blossoms, are assuredly not diminished in their impressiveness because the perhaps tyrannic sway of fashionable predilections, or of tastes subject to endless dispute, are left unobeyed in the exercise of the free judgment of science. When thus in youthful freshness the spring unfolds the tender leaves and discloses buds innumerable, then it awakens also here the earliest hopes of the rosy youth, or renews the smiles and faith of depressed spirits. And while all nature around rejoices in hopefulness, the swift arrows of Eros are sent also unerringly from yonder close green of dense retreats, whether created for stern science or idyllic enchantment only. Those who listen in affection from fragrant bowers to the warblers of the air will not discern whether yonder groves were intended to serve mere scientific grouping, or purposely formed to arouse some of the sublimest of sentiments. The soul, sunk in mournful sadness, will also find yet some consolation in a garden of knowledge, and will feel how the power of a Divine Providence pervades every leaf and flower; or the mind susceptible to the religious teaching of nature will there also recognise how the apparently lifeless root or grain sprout under the spring rays again with hopeful vitality from the cold darkness beneath— a symbol of an imperishable existence and of an eternity beyond this world.

"When spring's fair children pass away,
  When in the north wind's icy air
The leaves and flowers alike decay,
  And leave the rivelled branches bare;
Then from Vertumnus' lavish horn
  I take life's seed to strew below,
And bid the gold, that germs the corn,
  An offering to the Styx to go.
But when the hours in measured dance
  The happy smile of spring restore,
Rife in the sunny golden glance,
  The buried dead revive once more."

BULWER LYTTON, FROM SCHILLER.

THE MICROSCOPE.

A LECTURE,

DELIVERED BY SYDNEY GIBBONS,

On 23rd NOVEMBER, 1871.

ALTHOUGH I have much pleasure in addressing you on a favourite subject, I yet feel some little embarrassment, for I may mention, in the first place, that the subject is not of my selection. I should have preferred one admitting of experimental illustration, as I am in the habit, in the course of my practice as a teacher, of operating while I talk, and, therefore, even from force of habit, like to have something to do with my hands. Again, it is obviously impossible for me to pretend to show to all of you the objects themselves; still, although a friend of mine told me in this room that the lecture would be of no use without such demonstration, I will try with the instruments I have before me, and the drawings you see on the walls, to elucidate the subject. Another point that occurs to me is, that while in class lectures I am in the habit of at once plunging into the subject, giving out the heads, and then working them out step by step, the microscope is too discursive a subject to admit of that treatment, but requires much introduction; for, even in the first place, to explain its construction and operation we have to call in aid the two special sciences—optics and mechanics, to be followed by chemistry; and

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NOTE.—*This is a very much abridged report, in fact, a mere outline of the lecture, and several topics are altogether omitted. But it must be conceded that it was a difficult lecture to report, as much from the manner of delivery as from the number of technical terms and names which could not be excluded. Had I changed places with the reporter, I doubt if I could have done better for him. I have sketched in a few blanks, but memory is the only record I have of what was actually said.*—S. G.

when by these means we have our instrument completed and in working order, our sphere of action is then the domain of entire nature, diving into the earth to examine minerals, dissect fossils, then tracing vegetable growth, and so upwards till we come to the highest classes of animal structure, all distinct sciences within themselves, and not easy to link into a regular chain. We will, however, make some attempt towards it.

A public audience expects to be interested as well as instructed, and looks for something in the way of exordium. Now, I have not yet decided what kind of exordium I shall offer you, but may take a hint from Virgil, who, in dealing with a not very remote subject, expresses himself in terms which I may thus paraphrase, viz., that, "it being a minute one, some may consider it trifling, but the importance is not commensurate with the minuteness, nor is the honour and glory of dealing with it as small as the objects themselves;"* that is, he quaintly adds, "if the fates only let one alone, and Apollo hears when invoked." In another similar place† he promises not to detain his readers "with a made-up story, or by meandering or a long exordium." I would wish to follow his example.

Let us take the first object to hand (as I now do from the table before me) as a starting point. We look at it, feel it, and so acquire a certain knowledge of its more obvious properties, but say that for our purpose that does not suffice; we require to know more than our unaided senses can tell us—to enlarge the minute—to examine by increased light, transmitted from below or reflected from above—to obtain the relief of light and shade; in a word, we need the help of the compound microscope, of which by means of the model before me I will endeavour to show you the arrangement, and the passage of the rays through this combination of lenses producing the image required.

From every object perceived by us rays of light radiate in all directions, as instanced in the diagram before us of a lighted candle. Now the greater the distance we are from the candle the fewer of these rays enter our eye, for, suppose this foot-rule to be the diameter of the pupil, if I place it at a certain distance from the candle it receives four of the rays depicted; further off, two; nearer, six and more, and so on.

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* Georgic iv. 6. † Georgic ii. 46.

Now the apparent size of an object depends on its distance, and bearing this in mind, it follows that the farther off an object is from us the smaller is the angle it subtends at the eye. Instinctively, if we want to examine an object more minutely or with increase of light, we bring it nearer the eye, and when we can get some instrument to do that for us we have achieved much. Now, it is the lens that accomplishes this, the rays of light being bent and undergoing what is termed refraction in passing through it to form the image on the other side; and it is an important point to remember that the eye sees the object in the direction of the rays which enter the eye without reference to that of the rays outside the lens, the refraction being the greater according to the convexity of the lens; so that, as in the model diagram before us, the object presents itself to our eye, not in its real position and dimensions, but nearer and enlarged, because viewed under a higher angle.

The rays, having passed through the lens termed the objective, have to pass through a second and upper lens (the eye-piece) to reach the eye; and here let me mention that, although I have commenced by explaining the compound microscope, I might have introduced it to you in the first instance in its simplest form, viz., the ordinary pocket lens, familiar, I presume, to most of us, and with which a great deal of work may be done. Mount it on a pillar, and you transform it into one capable of adjustment; you may make one lens of the group an illuminator to another. If a higher power is required you have recourse to a Coddington, an excellent instrument, and far superior to the popular Stanhopes sometimes sold for it. Then there are the Wollastons, with one, two, or three lenses acting together, and magnifying the object itself directly, and not the image.

[The lecturer here went into some practical and technical illustrations of the construction and manipulation of the instruments before him, which cannot well be followed on paper, remarking that to such a delicate pitch had instruments been carried, that powers up to $\frac{1}{50}$th had been made, but that they were very difficult to use, and limited in their application; also as to various contrivances employed when an object that has been mounted before is again required for view, it becoming then sometimes a matter of importance and difficulty to find it, such as Maltwood's finder, a plate of glass on which a square inch is marked, divided into 100 each way, every square having two numbers, one for latitude, one for longitude; and which, by putting in the place of the object and duly marking, furnishes at any future time a certain indication to find the object; also the admirable contrivance of Powell and Leland, in which every stage movement is graduated, so that the position of the stage and of the object on it during any given observation can be registered. He then went on to say:—]

Let us now say something about the objects themselves, as illustrated on a magnified scale in the various drawings covering the wall before you, and which I may parenthetically observe are all supposed to be lighted from one point, and calculated to be best seen at a distance of about twenty feet.

I shall not trouble you with any remarks as to the mounting of objects for microscopic observations, but proceed at once to state that the first object that we have for consideration in dealing with organic matter is the cell, the primary form of which is that of a simple closed bag with contents, the form varying very much indeed, but the typical form being round; and the contents varying also greatly in both animal and vegetable products, but yet so closely allied in lower grades as to render it difficult to distinguish between them. A notion has sometimes been advanced that there is a gradual elevation of structure from the vegetable to the animal kingdom, and popular writers often mislead their readers by describing as "links" objects that appear to partake of the character of both. There is no such progression. The two kingdoms diverge from a common boundary, and that is the lowest type of each—viz., the simple cell, which it is often difficult to refer to its right place. Many mistakes have been made in this matter, and a large portion of the microscopic work being done now is the distinguishing between plants and animals, and referring back to the vegetable kingdom many objects formerly classed as animal, particularly by the celebrated German Ehrenberg, who, while it must be confessed that he has done enormous work, must also be charged with giving the microscopists of the present day a very large amount of work in undoing his classification, arbitrarily founded on hasty conclusions as to the existence of prehensile and digestive organs in what are now proved to be vegetable organisms destitute of both.

A simple vegetable cell consists of an outer coating called *cellulose*, nearly akin to the substance we know as wood; and inside that a thin lining, known as the primordial utricle, containing nitrogen, and it was this nitrogen that was for a long time one of the principal difficulties in the way of classifying the low forms of vegetable and animal life. Starch was considered at one time the distinguishing characteristic of vegetable, nitrogen of animal life; but now we find that substances very akin to starch exist in animal bodies, as in the base of the brain in man, so closely akin, indeed, that at present we do not know how to distinguish them from it;* while, as I have just mentioned, nitrogen is to be found in the inner lining of vegetable cells.

Inside this cell is the protoplasm, a viscid substance which is, in fact, the growing material, such being the signification of the term, and with it is generally to be found some colouring matter, as chlorophyle.

The figure I now draw your attention to illustrates the growth of the cell, which multiplies by simple division, a proceeding a little at variance with the ordinary course of arithmetic. First of all we see the protoplasm divide itself in the original bag, gathering itself into two bodies, and then the outer coating becoming constricted, these bodies are severed, and the development has taken place. Now let me draw your attention to this illustration of the plant *palmella cruenta*, or blood-rain. We hear sometimes of frogs in stones, of which there are no authenticated cases to bear proof, but there are other things nearly as wonderful, and one of them is the amazingly rapid growth of this plant; the blood-rain does not appear as a liquid, and no one sees it coming down, but it shows almost suddenly as clots of blood coagulated on the ground.

The main secret is that there is more moisture than anything else in its composition, and two solutions are open of the phenomenon; one, that it may have rapidly developed while, in fact, those observing it were under shelter; the other that it may have previously grown, but have dried up, and so remained undistinguishable until expanded by the falling moisture. Then we have red and green snow (as it is termed), occurring in the same way, which, in the Arctic regions, is found in great abundance. The same are also heard of in the Alps, the genus being named, from its very simple structure, *protococcus*. In this plant, then, and others of a like low organisation, which you see here pourtrayed, and which are called cellular, such is the operation of growth and division; there is no differentiation, as it is called—each part is alike, and each cell capable of living for itself, and like its progenitor; whereas in the higher plants you find organs set apart for special functions—one to form bark, one to make wood, others to form the fruit, the flower, and so on.

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* Lerp-Amylum, a constituent of the insect secretion on a variety of Eucalyptus (dumosa), is another example.

Now, proceeding a little higher in the vegetable scale, we come to a very curious object known as the *volvox globator*, which, by the way, was one of those described by Ehrenberg as an animal, but which may be simply described as consisting of a number of small vegetables enclosed in a common envelope, as here depicted. These plants are all aquatic, and have a remarkable power of movement, sometimes spinning along with great rapidity, at others remaining in one place but revolving with as great rapidity. It is a globe containing, or rather consisting of, a number of smaller ones, each of which is an individual, and is in due time discharged from the family group to enter upon its independent existence. Another illustration of this family before us is the *gonium pectorale*—so named from a fancied resemblance to the Jewish high priest's breast-plate—a group of sixteen cells spinning along on edge, and as the time arrives for each little plant to be sent into the world, it is simply cast off, and the remainder of the group goes spinning along without it. In course of time the one left opens into four, these each into four more, and so the original number of sixteen is arrived at.

Here again is the picture of the plant Zygnema, with several others akin to it, and known as *confervæ*, and which you will find in all the fountain basins in the Fitzroy Gardens, in the shape of a green, fibrous-looking fringe overhanging them. You remember the old fountain in Collins-street at the time when attempts were made to get up a panic about the Yan Yean water, and that when this green growth made its appearance on it, an outcry was raised that all that horrid green stuff was in the Yan Yean water, such simply not being the fact at all; the plant was local, and its growth was favoured by the constant moisture. It presents the curious phenomenon of conjugation, the adjacent cells on different plants uniting, and their contents blending, to form a *sporangium*, which ultimately gives rise to a new growth.

We now come to another class of objects which were regarded as animals by Ehrenberg, who appeared to have considered everything small and moving as an animal; but that test has been long since given up, for many plants are much more active than animals, moving with a rapidity indeed that would be incredible in an animal, while you cannot find a vegetable much quieter than the oyster, or, better still, the sponge.

We now come to the Diatomaceæ, of which each individual is complete in itself, but not having a skin or woody shell, but one of glass or silica. These shells are extremely beautiful and of endless variety of form, forming constant objects of interest to the microscopist. Amongst those here depicted I may briefly enumerate (pointing to each) the *actinocyclus*, a circle with rays; the *coscinodiscus*, the *eupodiscus*, the *triceratium*, the *Biddulphia*, the *Arachnoidiscus*, from its similitude to a spider's web. Of a slightly different class are the *Pleurosigma*, the *surirella*, the *gomphonema*, the *melosira*, the *navicula*, &c.

All these consist of two of the shells I have spoken of with a little organic matter inside; and in addition to these discs or other forms here depicted, of which there are two in each plant, there is also a little hoop of glass or silica connecting them. This hoop is elongated, the valves being pushed out, and a new pair of plates formed between the others, and then the two uniform bodies separate. Some of these forms adhere together, attached to a stalk, and this variation forms one means of classifying them; here is another kind, presenting the appearance of a row of little rods slightly adherent, but which keep on sliding nearly apart and then back again with great regularity.

Richmond, Virginia, U.S., may be said to be built on these objects, for the soil there contains them in abundance for miles; or, to come nearer home, here is a bottle of white powder representing a portion of the railway embankment at South Yarra, just by the tannery, familiar, probably, to most of you, and which has proved very rich indeed in these objects. Before the work was constructed there was a swamp there, and the earth was dug out from the sides and thrown up to form the embankment, but the ground being swampy the work sank down and the mud underneath oozed out, rich in the most beautiful forms, some forty different species being found in it.*

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* By Messrs. Ralph and Coates, who were before me in that field.

This subject of the South Yarra embankment suggests the remark that the nomenclature of these objects is somewhat confusing, and people at a distance from each other, finding some object new to them, often consider it new to all. There was one of the shells I have been referring to which was exhibited here as a total novelty, but within a week of its exhibition I received a letter from England asking me to send the writer some of "'that' *Stauroneis Fulmen,* from South Yarra," so that after all it proved to be known and named in Europe before it was recognised here.

But the feature which, more than the beauty of the forms, has endeared the *Diatomaceæ* to the microscopist, is the possession of delicate markings, varying in the different kinds, but tolerably constant in each. These markings, which usually consist of a groundwork of very fine lines, are, and long have been, used to test and compare some of the powers of microscopes. Not content with making out these lines—many thousand of which go to the inch—microscopists are ever striving to get beyond that feat, and to define what the lines are made of—whether mere dots, areolations, elevations, depressions, &c. Some of the earlier photographs showed these as hexagonal areolations, but more recent observation supports the view that the lines are rows of hemispherical elevations. For many years I have been satisfied that the lines in the *Pleurosigma formosum,* which I have most closely examined, are so formed; but when I made the observations, the microscopic world was satisfied with the views which are now going out.

We now come to speak of the spore which is formed by the union of a pair of cells, and which eventually becomes developed into a new plant. Several varieties appear in the drawings before us. We must not omit to notice here a very remarkable order of plants, viz., the *Desmideæ,* which nearly resembles the *Diatoms* in habit and mode of propagation. There is, however, this essential difference, that while the latter are silicious, the Desmids are wholly composed of vegetable matter, chiefly bright green colouring. They are found in sweet, pure waters, and in no others do they thrive. In this group—which represents the varieties that I have found in the Yan Yean—is seen a great variety of elegant forms, while in the adjacent drawings, representing the same water after contamination, as found in the gutters, but few are to be seen.

Ascending upwards in the scale we have to note the *fungi,* containing more nitrogen than some of the other plants, growing with great rapidity, and more or less characteristic of putrefaction, preferring decaying matter, chiefly animal. There are, in fact, some of the fungi which blow-flies mistake for meat.

These plants do not possess so much interest for us as those whose beautiful forms and curious habits have already occupied our attention; they are nevertheless of more real importance, since from their ranks we derive, on the one hand, esteemed delicacies, and, on the other, poison and the associates of disease. The scientific distance between the truffle of our *paté de foie gras*, the deadly amanita, and the *oïdium* of the fatal diphtheria, is hardly greater than between the rose, apple, and peach, which are all of the same natural order, rosaceæ. But I may mention two or three varieties. Apart from the mushroom and the truffle, there are several poisonous kinds; and others, again, which, although suspected, are still alleged by some to be very good and wholesome. Then we have the common mould, that beautiful little plant, of which cheese-fanciers are so fond. Viewed with a reflected light from one side, and with a binocular arrangement, it is a magnificent object for inspection, showing as a forest of little trees, each tufted with a crown of bright globules, and all the other moulds are more or less of the same kind. There is yeast, called by the Germans *ober* and *unter-hefel;* the *ober*, which is the aerial fructification, being diffused in the air as dust, the *unter* settling to the bottom. There is the *oïdium* attacking the grape, and that affecting the human throat in the case of diphtheria.

A remarkable fungus, which has given rise to the mistake formerly noted, is the Sphæria, found, among other places, in Tasmania; it has also been seen in the vicinity of Melbourne. I have seen in print vague accounts of the remarkable link between the animal and vegetable existing in a body, which was plant at one end and caterpillar at the other. It was this object, of which several are on the table, viz., the Sphœria, growing, as is its wont, out of the head of a caterpillar, which its germination as a parasite had killed.

Still ascending in the scale we come to ferns, and the peculiarity to notice here is the fructification, which consists of a large number of little capsules, or hollow cases, called sporangia, generated on the surface of the under side of the leaves, and shown in the diagram before us in the markings extending along the margin of the frond.

Each sporangium contains a number of granular particles, or spores, a something partaking of the nature of a seed, but still not a seed, but something from which the growth springs. This spore expands under the influence of heat and moisture, and develops into what is very much like a little leaf, and is called *thallus*, and from certain organs in that *thallus* a new plant is produced, distinct altogether from the spore.

We now come to plants of a more complex texture, where there is differentiation of organs, where one cell may go to form bark, one to form wood, another to the reproduction of species, &c.; but we have still cellular tissue, and organs formed from it, as, for instance, the strawberry, a fruit of very loose texture, with large cells preserving their rounded form. But when cells are compressed we get an hexagonal structure, network-like. And in this question of pressure we have to consider not merely the pressure itself, but its direction; thus, when the longitudinal increase is greater than that of breadth, or thickness, the cells are elongated while they are laterally compressed, and we have the fibres of wood; flax, which consists of such elongated cells joined end to end, may be quoted as a good example of woody fibre. In cases of very loose structures, where the growth of the plant is rapid, this internal pithy tissue is frequently torn away in the middle, and the pith is sometimes broken up into discs, or spirals. We get in some woody tissues markings of a peculiar character, sometimes spiral, sometimes disc-shaped, as instanced in this section of fern, showing ducts, or long hollow bodies, with traces of spirals. The seed of the common cress, when moistened, appears to exude a jelly; this consists of spiral fibres, forming originally the outer part of the shell of the seed, which the water releases from their confinement.

Another vicissitude occurs with regard to the process of filling up; in secondary deposit forms there is a continual deposition of matter taken as nutriment in the interior of the cell, sometimes soft, sometimes hard. In the core of the pear, for instance, there is, as you know, a gritty portion, that gritty portion consisting of a number of these cells flattened. In some rushes the cell is altered from its round form into a star, the rays of which spread out to reach their neighbours. A denser variety, in which the cells are nearly filled with the hard deposit, constitutes nut shell.

The diagrams now before us show the arrangement of the stomata or breathing pores existing in great numbers, chiefly on the under sides of the leaves of plants, by which the air and moisture are taken up and passed into the cavities inside, as instanced here in the oleander, where a cavity is protected by a number of hairs furnished with a multitude of pores; or again in the balsam. These views of the cuticle of the lily and aloe show the peculiar arrangement of the cells by which those immediately surrounding the opening form lips which almost seem to serve as valves.

Another feature worth notice is that of the crystals existing in many plants, found to be principally composed of oxalate and phosphate of lime and other similar earthy salts.

Among the most important of the vegetable matters of which the microscope takes cognisance, and one in which its usefulness is remarkably shown, is starch. Although all starch is starch in a chemical sense, there being no difference of composition between the expensive arrowroot of Bermuda and the similar product of the humble potato, still the difference of form is very great, and by the aid of the microscope the starches of known plants can be distinguished with unerring exactness; not merely for the detection of adulteration or substitution, but as data useful to the juridical expert, who utilises items of information in which others would not perceive any pertinence.

The use, too, of polarised light, which marks each individual particle with a black cross, is in such observations of singular value, as from mixed fields it instantly weeds out all the starch, leaving us the residual matters to deal with.

We now come to animal life, the simplest form being indistinguishable from the simple vegetable cell, a rounded hollow bag with something in it, and very often little cilia or filaments attached to it by which it swims about.

Starch and nitrogen, although useful aids, are not then sufficient in themselves to distinguish between animal and vegetable, and we have already seen that motion, power of selection, and apparent volition are highly deceptive. Fortunately, with the discovery of the fallacies attending the old tests, new and more satisfactory ones have been acquired. Plants assimilate simple substances from the inorganic kingdom, and build them up into complex forms. Animals require for their food these complex bodies, which by decomposition they ultimately simplify.

The Proteus, so called from the multitude of forms it can adopt, is merely a little dot of jelly containing a few bubbles, lazily rolling itself along in the water without limbs or organisation. But it makes what limbs it wants when it wants them. You may see it pushing forth something like a leg, and then another, sometimes apparently for diversion, but at other times for locomotion or food. When it swims or rolls up against anything good for food, it simply surrounds its dinner, forming its whole body into an extemporaneous stomach.

Closely akin to this, in fact belonging almost to the same class, are some beautiful objects, which for a long time were placed higher up in the scale, the Foraminifera.

They have extremely beautiful shells, of most elegant forms, all very minute, but still varying much in size, although the largest does not exceed the size of a very small pin's head. They are very widely diffused, so much so, that by a figure of speech the pyramids may be said to be built of them, as they are built of stone, which consists in greater part of these fossil shells; and to refer to a more familiar subject, you find them plentifully in new sponges.

Then come the Polycystina, very beautiful shells, varying much in form, and composed of silica.

[The lecturer said that he had refrained from encumbering the minds of his hearers with any more technical nomenclature than was necessary. To show that such as he omitted would profit them but little, he recited the names of a dozen of each of the last two genera which formed the illustrations.]

And now having worked up to animals, I think I may introduce you to the waters, in which, as was the case with plants, we find the simpler forms. Here is a group showing the natural history of the Yan Yean in 1859, all animal and vegetable forms, but yet consistent with perfect sweetness and wholesomeness of the water, for this very good reason, that the majority of them would not live in anything else. Several of these animals are furnished with cilia round the mouth in continual motion, producing the appearance of a wheel going round, or like that peculiar appearance you may have observed in a field of corn when moved by the wind, and appearing to progress, but not doing so in reality. Hence these animals are called *Rotifera*, the object of the motion appearing to be the attracting, as with a whirlpool, smaller animals into the vortex of the mouth. This drawing represents a comparatively large animal of this species with two wheels, and a very pretty experiment may be made with some dry particles of carmine or indigo thrown into water with these animals, when the floating particles indicate the direction of the current.

A word or two now about parasites, and to which I ask your particular attention. They are very ugly and very injurious, and they are external and internal.

There are external ones, such as the flea and bug, microscopically beautiful, and some very remarkable ones of the family of the Ixodes. If you kill an opossum you are certain to find in one, if not in each ear, one individual of this family, with a curious kind of mouth opening outwards with a kind of claw similar to a "lewis," a tool used by masons for raising stones, and which proboscis the animal will suffer to be torn off before it gives way. There is the Demodex, living in or near the skin of animals, and not migratory; as, to take a familiar instance, in the region of the face, chiefly in the neighbourhood of the nose, are specks, which, on being squeezed out and examined, are found to contain minute animals, something like maggots; unlike other parasites, this kind bears no relation to either disease or dirt. Here is a magnified photograph of the sheep scab, Sarcoptes ovis, from this original specimen, and here is an enlarged drawing of the animal. But the class of parasites I wish more particularly to speak about is that of *Entozoa*, an internal one, living within us; not a very pleasant subject, but a most important one.

The *trichina spiralis* is ordinarily known as indicative of measly pork, although the name measly is rather a misnomer. Here is a view of muscle containing an oval-shaped bag termed cyst, in which is coiled up the parasite. This is found very generally in pork; it is scarcely possible for any but dairy-bred and dairy-fed pigs to be without it; in fact, I very much question whether any pig exists that is free from it. It is commonly said that pork ought to be well done, but I assure you these things take a good deal of doing, for in some stages of existence there are both animals and plants that survive an enormous amount of ill-treatment; and it is a question among naturalists of the present day whether boiling is sufficient ill-treatment. Many germs are known to survive a temperature of 300° Fahr., hence the mistakes of those who entertain the idea of spontaneous generation, and who fancied that because they boiled their preparations all germs had been excluded. So far from this being the case, recent rigorous experiments have shown that some of the germs, both animal and vegetable, the destruction of which is most desired, will endure remarkable vicissitudes of temperature, and even resist many reagents. These (trichinæ) are particularly long-suffering creatures. Many people are in the habit of eating pork slightly done; in Germany, for example, it is often merely smoked, with but little more cooking; and in that case the trichina simply becomes an inhabitant of human muscle, increasing and multiplying very rapidly. That such is the fact is exemplified by this portion of human muscle, taken in Melbourne, and which has multitudes in it. I do not suppose that Moses knew anything about the trichinæ, but the disease they cause may then have been known; and the prohibition of pork in a hot climate is undoubtedly a wise thing. The two drawings to which I now direct your attention show the figures under different conditions of a variety of the tape-worm, sometimes growing to the length of 30 or 40 feet. This kind normally inhabits dogs; and there is every reason to believe that the presence of them in human beings is often due to carelessness in allowing children to play with dogs, and the latter to lick their faces. I have here some ugly things for which I am indebted to our health officer, Mr. Girdlestone. They were taken from a pork kidney, and belong, we believe, to a kind called *strongylus.* But at present the kinds best known are extremely large, and whether these are young ones or a variety is not yet determined, but probably soon will be; for while the kidney was under examination, a cat stole a portion of it, and from a plump, fine animal it fell away, and is now decidedly out of condition. It will soon be sacrificed in the cause of science; so that the fate of that marauding cat may point a moral, and its tail adorn—a museum.